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sediments," lying below the made ground and old foundations of some new buildings being erècted in Clive Street, Calcutta. They formed a bank about half a foot or less in thickness situated some five feet below the level of the street—an underlying stratum about a foot in thickness consisted of black mud. The extent of the marine bed with the oysters covered a space of at least a hundred feet square, and it was regarded as being on one uniform level. The oysters, themselves, occurred in layers, but sometimes were isolated. Col. A. W. Alcock had recognised the shells as "identical with a large species of oyster which lives in large numbers in the mud banks near the mouths of the channels of the Sunderbands," such specimens having the umbonal part of the shell and the ligamental pit often growing to a considerable length, a character most prominent in the Clive Street examples. the ligamental region sometimes reaching a length of eight inches, besides being straight or curiously curved. Proceeding, Mr. Vredenburg mentioned that "judging from their large size and robust appearance, it is improbable that these shells could have flourished much above low-water mark, implying a relative position of the sea and land decidedly different from that obtaining at present. The altitude of the Calcutta oyster-bed is scarcely ever reached even by the highest spring-tides in the Hooghly river. Sufficient data are not available to decide whether this indicates a change of level in the sea or in the land." Quite recently Mr. Vredenburg in an interview with one of the writers has stated that the oyster-bed occurs *in situ*, and is geologically of very modern age. He believes that the oysters existed where they are now found on account of their occurring at a greater height than the present sea-level.

A number of other shells were said to be found about the mud-heaps at the side of the trenches including:—*Telescopium fuscum*, Chemnitz, a species common in the oyster banks of the Sunderbands; forms of *Arca*, *Anomia*, *Ampullaria*, *Paludina* and *Planorbis*. Barnacles and Serpulæ also occurred, but, according to Mr. Fermor, the freshwater shells were mostly obtainable in the layer of mud underlying the oyster-bed. This oyster-bed was again alluded to in Sir T. H. Holland's[1] General Report of the Geological Survey of India for 1903-1904, and the following state-

[1] *Records, Geol. Surv. India*, 1905, Vol. 32, p. 136.

ment connected therewith may be quoted :—"The discovery in July last of an old oyster-bed in Calcutta at a level well above present high-tide mark shows that, besides the general depression which has occurred to permit of the accumulation of alluvial deposits in the Gangetic delta, there have been oscillations also of the relative level of sea and land during recent geological times." Polyzoan structures were occasionally found adherent to the same oyster-shells, and these were submitted to Mr. A. W. Waters[1] for determination, who published a note upon the subject in 1908. He referred to the organism as being like *Lepralia* (*Escharioides*) *occlusa* of Busk, and possibly a marked variety of that species "or an ancestor." It may be mentioned that Busk's species is localised in the Challenger Report (1884, p. 150) as Cape York, Australia, and Samboangan, Philippines. Dr. Annandale[2] appears to have made the last published remark on this subject. He contributed a full list of the organisms found in the Clive Street deposits, and acknowledged assistance rendered by Mr. H. B. Preston in determining the mollusca :—

> *Telescopium fuscum*, Chemnitz
> *Paludina* (*Vivipara*) *bengalensis*, Lamarck
> *Ampullaria globosa*, Swainson
> ? *Aricia moneta*, Linnæus
> *Planorbis exustus*, Deshayes
> *Anomia achæus*, Gray
> *Arca adamsoniana*, Dunker
> *Ostrea cucullata*, Born
> *Ostrea canadensis*, Lamarck
> *Balanus patellaris*, Spengler
> *Lepralia* (*Escharioides*) *occlusa* (var.), Busk

and in addition a fragment of mammalian bone, certainly carnivorous, probably a large dog or wolf.

It will be observed that the large oyster with the elongate hinge is referred to in the list as *O. canadensis*, which according to Dr. Annandale was Mr. Preston's determination confirmed by Mr. E. A. Smith, the following remark being added : "how it (the

[1] A sub-fossil Polyzoan from Calcutta : *Records, Indian Museum*, 1908, Vol. 2, pp. 109, 110.

[2] Second note on a Recent Estuarine Deposit below Clive Street, Calcutta : *Records, Geol. Surv. India*, 1908, Vol. 37, pp. 221-223.

oyster) got to Calcutta except as ballast, it is difficult to imagine." It should be observed, however, that only a single valve was sent to Mr. Preston and without the information that "many" had been found "in the deposit." Dr. Annandale stated, as previously announced by Colonel Alcock, that similar oysters occur living in the Sunderbands (the lower portion of the Ganges delta); the same species being found also at Mergui, Penang, and Cutch. The whole facies of the deposit he regarded as recent.

Having reviewed what is known concerning these supposed geological deposits found a few feet below Clive Street, Calcutta, it may be of interest to recall an important paper by the late H. B. Medlicott[1] on "Artesian Borings in India" published in 1881, which described the depth and characters of the alluvial formation on which Calcutta stands, based upon information obtained from a boring made at Fort William between 1836 and 1838, which reached a depth of 481 feet. The different layers passed through consisted of carbonaceous matter (peat), clays, sands, quartz gravels, blue marl with shells; and at the base, sand with pebbles of primary rocks, fossil bones and decayed wood. Throughout this great thickness of alluvial strata no marine beds were detected so that they must have been deposited either by freshwater or estuarine agencies. At considerable depths, bones of terrestrial mammals and fluviatile reptiles were found, but the only fragments of shells noticed at 380 feet are said to have belonged to freshwater species.

From our knowledge, therefore, of the alluvial structures on which Calcutta is built and the absence of marine conditions throughout the great extent of those deposits, it seems apparent that the Clive Street oyster-bed does not form part of that series of strata and cannot therefore be of any geological importance.

It has been suggested by our friend Lieutenant-Colonel H. H. Godwin-Austen, F.R.S., that these oysters were brought to Calcutta in native craft from elsewhere, and collected on the Clive Street site for burning into lime, perhaps in the earliest days of our occupation of Calcutta, and as was done for years after, certainly up to the early fifties in the vicinity of Calcutta—previous to the time when Calcutta began to be supplied with lime manufactured at the base of the Khasi Hills. This lime is brought down in such quantity that the old method of shell collecting has

[1] *Records, Geol. Surv. India*, 1881, Vol. 14, pp. 205-237.

died out. It came under his own observation and he has lately seen a note by the late Dr. W. T. Blanford attached to a species of *Unio* found at Chingarri Ghat Saltwater Lake, Calcuttà, "brought thither with other shells to burn into lime." One of the commonest shells thus collected was *Telescopium fuscum.*[1]

The shells were easily procurable from the Sunderbands, or any of the other regions in the Bay of Bengal where oysters of large size and further shells like *Telescopium fuscum*, etc., flourish at the present day. They would be probably collected in boats, then taken up the Hooghly, and finally shot out on to the plot of ground now known as Clive Street. We are inclined to think that this is the most plausible explanation that could be offered for the presence of these oysters beneath the City of Calcutta, because, as pointed out by Colonel Alcock and Dr. Annandale, the species still exists in the mud banks of the Sunderbands.

But although of no geological importance in connection with the structure of Calcutta, the oysters themselves present certain characters which unmistakably connect them with a Miocene form generally referred to *crassissima* of Lamarck. So far as can be ascertained, the large oyster of the Bay of Bengal has never been accurately determined, and although superficially it may appear to resemble *canadensis* of Lamarck, as supposed by Mr. Preston, there are certain characters which distinctly separate it from the Atlantic form found off the coasts of North-Eastern America.

We are of opinion after a close and exhaustive comparison with the large living forms found in the Bay of Bengal that the oysters of the presumed geological deposit at Calcutta and the so-called *crassissima* of the Miocene period belong to one and the same species. It will be necessary, therefore, to consider the history of this fossil form which, according to the modern specimens from India, is now regarded as surviving in recent seas.

Among his group of non-plicated fossil oysters, Lamarck

[1] As another instance of oyster-shells being utilized for the manufacture of lime it may be mentioned that Conrad referred to the subject in 1834 (*Journ. Acad. Nat. Sci. Philadelphia*, 1834, Vol. 7, Part 1, p. 156) when describing his species *Ostrea georgiana* from the probable Oligocene rocks of Georgia and South Carolina in the United States, which reached a measurement of 22 inches and was also remarkable for its elongate cardinal region. He further stated "it is extensively quarried, to be converted into lime, in those districts where it abounds."

described in 1819 *Ostrea crassissima*, without knowing its locality, referring to it as a shell of very large size and often of extraordinary thickness, and said to be more related to *virginica* than to his succeeding species, *longirostris*. The diagnosis was as follows:—*testa elongata, crassissima, ponderosa, rostrata; rostro longo, lato, canaliculato, transversim striato, apice subuncinato.*

A modern example was quoted which in the ordinary way would be accepted as the type. this being an *Ostrea* figured by Chemnitz in his "Conchylien-Cabinet" of 1785, which has been since recognised as the *virginica* of Gmelin from the Atlantic side of North America both by Lamarck himself (*Ann. Mus. Hist. Nat.* 1806, Vol. 8, p. 162) and subsequent authors. It is interesting to note in this connection that Deshayes in 1836 (2nd Edition of Lamarck's *Hist. Nat. Anim. Sans. Vert.*, Vol. 7, pp. 242, 243) had examined the fossil shell to which Lamarck had given the name *crassissima*. and doubted whether the Chemnitz figure represented it. "Nous doutons beaucoup que la figure citée de Chemnitz la représente." Deshayes further remarked that the Lamarckian fossil agreed very well with Fichtel's figures on Pls. 5 and 6 (Nachricht Versteinerungen Siebenburgen Mineralien Fossilien, 1780) which were fossil examples from the Miocene rocks of Austria.

It would, therefore, appear from this explanation that (the figure quoted by Lamarck for his *crassissima* in reality representing the *virginica* of Gmelin's 13th Edition of the Linnæan "Systema Naturæ,") the former name should never have been adopted for the fossil shell under consideration. As a matter of fact, however, Schlotheim had already recognised the same oyster in 1813 as *Ostracites gryphoides*, which was six years prior to the establishment of Lamarck's *crassissima*, so that on account both of priority and clearness that name should be resuscitated.

Schlotheim gave no description of the oyster to which he had applied the specific name *gryphoides*, but he quoted some excellent old figures published by Fichtel in 1780 as representing examples which came from the Tertiary deposits of Siebenburgen in the Transylvanian region of the Austrian Empire.

We have come to the conclusion that the specific name *gryphoides* should be applied to the Miocene oyster so long known in modern years as *crassissima*, as also to the recent form from the Bay of Bengal which we consider in every way as possessing identical characters.

SYNONOMY AND ITS EXPLANATION.

Ostrea gryphoides, Schlotheim.

Fichtel: Nachricht Versteinerungen Siebenburgen Mineralien Fossilien, 1780, Pl. 4, fig. 9, and Pls. 5 and 6, pp. 87, 88.

Ostracites gryphoides, Schlotheim: "Beitr. Natur. Verstein. geogn. Hinsicht," *Taschenbuch Mineralogie,* 1813, Vol. 7, p. 52.

Ostrea crassissima, Lamarck: Hist. Nat. Anim. Sans Vert., 1819, Vol. 6 Part 1, p. 217. (Excluding reference to Chemnitz).

Ostrea longirostris var. C., Goldfuss: Petrefacta Germaniæ, 1833, Vol. 2, Pl. 82, fig. 8, p. 26, *non* Lamarck.

Ostrea crassissima. Deshayes and Milne Edwards: 2nd Edition of Lamarck's "Hist. Nat. Anim. Sans Vert.," 1836, Vol. 7. pp. 242, 243.

Ostrea virginica, Dujardin: Mémoire Couches Sol Touraine, *Mém. Soc. Géol. France*, 1837, Vol. 2, Part 1, p. 271 (*non* Gmelin; although not figured this form is in all probability *O. gryphoides* of Schlotheim).

Ostrea crassissima, Marcel de Serres: Observations grandes Huîtres fossiles Tertiaires Mediterranée. *Ann. Sci. Nat.* (Paris), 1843, Ser. 2, Vol. 20, pp. 142—168; Bayle in Fournel: Richesse Minérale de l'Algerie, 1849, p. 376; Raulin and Delbos: Monographie des *Ostrea* des Terrains tertiaires de l'Aquitaine, *Bull. Soc. Géol. France*. 1855, Ser. 2. Vol. 12. pp. 1144—1164; Raulin, V.: Description physique de l'île de Crête, *Actes Soc. Linn. Bordeaux*, 1860, Vol. 23 (or Ser. 3, Vol. 3), p. 373; Fischer, P.: Faune Tertiaire Moyenne, in Tchihatcheff's "Asie Mineure" Paléontologie, 1866-1869, Pl. 19, p. 253; Hoernes and Reuss: Die Fossilen Mollusken Tertiaer-Beckens Wien, 1870, Pls. 81—84, p. 455 (*Abhandl. k. k. geol. Reichs.*, 1870, Vol. 4); Fischer and Tournouër in Gaudry's "Animaux Fossiles Mount Léberon," 1873, p. 141; Carez: Études Terrains Crétaces et Tertiaires du Nord de l'Espagne, 1881, p. 278.

Ostrea maresi (Munier-Chalmas, MS.), Kilian: Mission d'Andalousie, *Mém. Acad. Sci. France,* 1889, Ser. 2, Vol. 30, Pl. 34, fig. 2, Pl. 36, fig. 2, p. 712 (fig. 3 woodcut), *non* Coquand.

Ostrea barroisi, Kilian: *ibidem*—see explanation to Pl. 34, *non* Choffat.

Ostrea welschi, Kilian: *ibidem*—see "Table des Matières," p. 760. (*Note.*—Professor Welsch is of opinion that this form of

Ostrea for which the three above names have been proposed is the equivalent of *O. crassissima=gryphoides*).

Ostrea crassissima, Philippe Thomas: Étage Miocène et valeur stratigraphique de *l'Ostrea crassissima* au sud de l'Algérie et de la Tunisie, *Bull. Soc. Géol. France*, 1892, Ser. 3, Vol. 20, p. 3, and Desc. Foss. Tert. Second. Tunisie, *Explor. Scientif. Tunisie*, 1893, p. 18; Jules Welsch: Études Miocène Algerie, *Bull. Soc. Géol. France*, 1895, Ser. 3, Vol. 23, p. 287.

Crassostrea crassissima, Sacco: Molluschi Terziarii Piemonte (Torino), 1897, Vol. 23, pp. 15, 16.

Ostrea crassissima, Dollfus: Mollusques Tertiaires du Portugal, *Com. Service Géol. Portugal*. 1903-1904, pp. 12, 21; Doncieux: Note Tert. Quatern. Sud-Est de l'Aude, *Bull. Soc. Géol. France*, 1904, Ser. 4, Vol. 3, Part 1, pp. 695—710.

According to Marcel de Serres'[1] memoir on the large Tertiary oysters from Mediterranean Countries, De Joubert[2] from 1774 to 1777 was among the first observers to collect and study such fossils which came from various localities in Central France (Pouget; Gigane; Gabian, etc.), he being of opinion that their living analogues were to be found in the seas of the East Indies.

Fichtel's specimens described in 1780 were collected in the Siebenburgen province of Austria. Schlotheim's shells which, in reality, were represented by Fichtel's illustrations, were localised as from the Italian side of the Alps. The habitat of the original *crassissima* is left blank, so that we can only imagine that Lamarck was uncertain from whence his fossil examples were procured. The *longirostris var. C.* of Goldfuss is said to have been obtained from the upper "Meersande" near Hohen-Memmingen, and Giengen in Wurtemberg. Deshayes' reference to *crassissima* concerns Lamarck's fossil which was without locality; whilst Dujardin's determination of *virginica* evidently included *gryphoides* as now understood, his specimens having been collected in the Tourains district of France, where this large species occurs in some numbers. Marcel de Serres recognised Lamarck's *crassissima* under his group of "Huitres allongées" and placed it among those

[1] *Ann. Sci. Nat.* (Paris), 1843, Ser. 2, Vol. 20, pp. 142—168.

[2] *Mém. Soc. Sci. Montpellier*, 1777, p. 17, and *Mém. Math. Phys. Acad. Sci. Paris*, 1774, Vol. 6, pp. 83—91. (These works by De Joubert have not been seen by the present writers; they are here referred to on the faith of Serres.)

forms which possessed "A canal distinct au sommet de la valve inférieure." He repudiated Joubert's suggestion that fossil examples from Central France resembled recent oysters found off the East Indies, and regarded rather that a truer relationship existed with *O. canadensis* of Lamarck (=*virginica*, Gmelin) found off the coast near New York.

In their monograph on the Tertiary Oysters of South-Western France (Aquitane), Raulin and Delbos recognised *crassissima* as belonging to their Section "Virginicæ," which included forms with a wide canal occupying $\frac{2}{5}$ or $\frac{1}{2}$ of the ligamental surface; the left or lower valve possessing slightly fimbriated or plicated lamellæ, and with a very prolonged rostrum; right valve smooth. In his memoir on the Island of Crete, Raulin lists *crassissima* as occurring in the sub-appenine formation (=Miocene) of that country. An extended account of this oyster and its geographical distribution through the "Tertiaire Moyenne" of Mediterranean Countries was given by the late Paul Fischer in Tchihatcheff's "Asie Mineure." He proved its occurrence as far eastward as the neighbourhood of Tarsus in Asia Minor. He quoted the dimensions of various forms found in the European Tertiaries, among which was one collected by De Verneuil in Spain (Lorca, Murcia) stated to have a total height of 18 centimetres and 15 in length with a cardinal surface measuring 20 in height which is probably one of the largest specimens known. Some remarkably larger forms have been figured by Hoernes and Reuss from the Miocene beds of the Vienna Basin, one particularly exhibiting a ligamental rostrum of nearly nine inches in extent and a maximum width in the same region of seven inches, this specimen, Pl. 1, resembling in every way one of the valves from Calcutta although possessing a much more produced ligamental surface, the Calcutta specimen measuring only six inches in that region.[1] This great specimen from the Vienna beds is even larger than the one previously mentioned as from Spain which had been collected by De Verneuil. Paul Fischer and Tournouër included this fossil in their account of some invertebrate remains from Mount Léberon, Central France, and referred to it as having been collected in the "Marnes de

[1] The Calcutta example here mentioned is the one in front of us at the time of description; but, as already referred to, Mr. Vredenburg had noticed a valve with a ligamental region extending to a measurement of eight inches or 20·2 c. m.

Cabrières," which is of Helvetian-Tortonian age. An example is referred to measuring 270 millimetres high and 65 mm. long. These authors regarded *crassissima* as being evolved from the European Eocene, thence through *longirostris* of Oligocene (Tongrian) age, *gingensis* from the faluns of Bazas (Aquitanian), on to the typical *crassissima* (Vindobonian), and so ultimately to the living forms of the North-East American coast known as *virginica* (=*canadenis*).

The species has been recorded from the North of Spain by Carez, whilst Kilian has described it from the Andalusian Miocene (South of Spain) as *Ostrea maresi*, which name he afterwards altered to *barroisi* because of preoccupation, and subsequently to *welschi* for similar reasons. Professor Welsch[1] of Poitiers, however, who is the chief authority on the *crassissima* (=*gryphoides*) beds of Algeria, is of opinion that M. Kilian's shell is none other than *gryphoides*. Philippe Thomas referred to the same shell as occurring in the upper part of the Miocene of Tunis where it is frequently associated with *O. gingensis* of Schlotheim; he also noticed it from Southern Algeria. Professor Welsch has shown its distribution in Algeria regarding the species as peculiarly Helvetian.

Dr. Sacco founded the sub-generic name of *Crassostrea* for Gmelin's *virginica*, and included *crassissima* (=*gryphoides*) as the fossil example, on account of the peculiarities of the cardinal area and its general elongate contour, etc. He regarded the species as ranging from Helvetian to probably Astian times. The species has also been recorded from the Tortonian and Helvetian rocks of Portugal by M. Dollfus.

Lastly M. Doncieux when describing some Tertiary beds from the South of France (Aude) recognised a series of graduating species among the longirostriform Ostreas :—

Ostrea angusta, Deshayes—Sables de Cuise=*Eocene*.
Ostrea longirostris, Lamarck—Stampian=*Oligocene*.

Ostrea aginensis, Tournouër *Ostrea crassissima* var. *minor*, Doncieux	Aquitanian to Burdigalian	=*Miocene*.
Ostrea gingensis, Schlotheim *Ostrea crassissima*, Lamarck (type)	Vindobonian	

[1] This information was given to one of the present writers during a visit made by Professor Welsch to the British Museum (Natural History), in the summer of 1910.

It was remarked also by this author that *Ostrea virginica* living off Virginia in the United States may possibly be considered as a direct descendant of *Ostrea crassissima.*

The true *Ostrea gryphoides* (=*crassissima*) has not yet been recorded from Egypt although Mayer-Eymar in 1887 referred to it as occurring in the upper Miocene deposits of the Gebel Zeit area (in L. H. Mitchell's "Ras Gemsah and Gebel Zeit—Report on their Geology and Petroleum" (Cairo), 1887, p. 34), but that determination was not accurate and it has since been altered by Dr. Blanckenhorn to *Ostr a gingensis,* Schlotheim var. *setensis* of Blanckenhorn (Neues zur Geologie und Paläontologie Aegyptens—Das Miocän: *Zeitsch. Deutsch. Geol. Ges.*, 1901. Vol. 53. p. 117, woodcut fig. 10), which is an elongate oyster with prominent ligamental area like *gryphoides* but possessing the outer plicated sculpturing of *gingensis.*

The only instance of the geological occurrence of this oyster in India that we have been able to trace is a statement in a paper by Mr. Vredenburg to the effect that Mr. Murray Stuart had determined the presence of *O. crassissima* in sandstones overlying the Kama clay in the Henzada district of Burma, supposed to be about the "Grund" horizon of Europe and consequently of Helvetian age. (*Records Geol. Surv. India,* 1911, Vol. 41, p. 37.)

It now remains to give some account of the oysters found under Clive Street, Calcutta, and also of the specimens sent us by the Indian Museum as coming from Mergui which belong to the same species and which Colonel Alcock assures us still occurs living at the present day in the Sunderbands.

Another large series of oysters from Hukitola, near False Point on the Cuttack coast, which may be regarded as a marked variety, has also to be described.

DESCRIPTION OF THE SPECIMENS.

Ostrea gryphoides, (Schlotheim). (Pls. 1—6.)

The first series embraces the typical forms of *O. gryphoides* which are remarkable for the prolonged form they attain at maturity.

In the young stage the shells (10—15 mm. across) are quite rounded, and then commence to become somewhat ovate, gradually adding to the ventral margin of the valves, rather than at the sides, so that the increase of growth tends to prolong the shells, and not to widen them to the same extent. Beyond the concentric lamellæ of growth the valves exhibit very little sculpture. There is, however, upon the earlier portion of the upper or non-attached valves evident traces of elevated radiating ridges, which can even be noticed further down the valves in one of the better preserved specimens. Another noticeable feature is the flatness of the valves, there being very little difference in this respect in either the upper or lower one, the former, however, being as a rule a trifle the flatter. The greatly prolonged ligamental area is also a most striking feature, reaching the length of nearly six inches in one of the specimens dug up in Calcutta (Pl. 3) and another eight inches in length according to Mr. Vredenburg's statement, previously referred to. It always exhibits a marked curve, especially in the earlier stages of growth. There is, however, no constancy in the direction of the curve, and it may be either to the right or the left. The area in the lower valve is hollowed along the middle, with a raised ridge on each side of the excavation. It is marked with distinct lines of growth and a few rather prominent ridges in the same direction, and is also covered throughout with fine longitudinal striæ. In the upper valve the area is broadly convex down the middle, the convexity corresponding to the excavation in the opposite valve. It is also similarly striated in both directions and ridged across. The valves with age may become enormously thickened, the valve already referred to with the very long ligamental area being two and a half inches through at that place. The lamellæ of growth are of a dirty purplish brown colour, but the shell itself beneath the lamellæ is much paler or whitish. The interior of the valves is pure white excepting the muscular impression which is very pale dirty brown or dirty whitish and forms quite a contrast to the rest of the surface. The form may be described as irregularly heart-shaped, the upper outline being curvedly indented or sinuated. It measures as much as 45 mm. in diameter, both longitudinally and transversely. In one of the fifteen valves examined the form of the scar is rather different, and may be described as narrowly reniform, and very like that observable in most of the specimens of the variety occurring at False Point on the Cuttack coast,

EXAMPLE FROM THE CALCUTTA EXCAVATIONS. (Pl. 3.)

Dimensions.

Lower valve . . . . $\begin{cases} 14\frac{1}{2} \text{ inches } (=38 \text{ c.m.}) \text{ in height.} \\ 6\frac{3}{4} \quad " \quad (=17 \text{ c.m.}) \text{ " length.} \end{cases}$

Height of hinge-area $5\frac{1}{2}$ inches (=14 c.m.), width 3 inches (=7·6 c.m.)

The specimen is rather broken at the lower margin so that when complete it probably had a height of about 16 inches (=40·5 c.m.)

Ostrea gryphoides, var. cuttackensis, *var. nov.*

Shell less prolonged than in typical specimens of *O. gryphoides*, and having the lower or attached valve rather deeper than in that form. The ligamental area is of the same character, similarly sculptured, curving generally to the left (judging from the series of about thirty specimens under examination), but occasionally to the right. It is variable in length from about two to three and a half inches in the lower valves of adult specimens. The exterior is lamellated as in typical *gryphoides*, and upon the upper or flatter valve, towards the umbonal region, distinct traces of radiating ridges are observable. The interior is pure white, with generally an irregular stain or two of an olivaceous tint. The muscular impression is usually narrower than in the typical form, but occasionally almost of the same shape. It is certainly whiter, but this may be due to the fresh condition of the shells. The typical specimens of *gryphoides* before us are dead shells, so that the colour of the scar may alter with time and exposure. Many of the scars in the present form exhibit one or more olivaceous bands—parallel with the curve of the outer margin, and also obscure transverse striation.

The above differences between these two forms are probably due to differences of environment. The typical *gryphoides* living in the quieter waters of the Sunderbands would probably have a tendency to more regularity in growth. On the other hand the specimens from False Point on the Cuttack coast would be much more exposed to rough seas, and are found in large masses one upon another, thus modifying or preventing uniformity of outline. It is of interest to note that a short form of oyster occurs in the

Calcutta excavations (Pl. 8, fig. B) which strongly resembles this variety.

Reference has been made by some writers to the similarity between *O. gryphoides* and the North American *O. virginica* of Gmelin, but besides differences of form, the colour of the adductor scar readily distinguishes the two species.

Although both in the adult state become very elongate, yet *O. gryphoides* is a much bulkier shell, and not so narrow. The umbonal end in *O. virginica* is more acuminate also. With regard to the muscular impressions, that in the latter species is invariably purplish black, whereas in *O. gryphoides* it is practically white.

EXPLANATION OF PLATES.

[The figures represent specimens delineated two-thirds of the natural size.]

Ostrea gryphoides, Schlotheim.

PLATE 1.—Ligamental area of a large specimen from the Miocene (Helvetian-Tortonian) beds of the Vienna Basin—copied from Hoernes' "Mollusken Tertiaer—Beckens Wien": *Abhandl. k. k. Geol. Reichs.*, 1870, Vol. 4, Pl. 84, p. 455.

PLATE 2.—Internal view of the upper portion of a lower valve from the Miocene (Helvetian-Tortonian) deposits of Mercier-la-Comte, Algeria. Collected by Dr. Sequin. Presented to the Geological Department of the British Museum by Professor Jules Welsch.
Height=36 c.m. *Length*=15 c.m.

PLATE 3.—An adult example showing internal characters of a portion of the lower valve, obtained from the Clive Street excavations at Calcutta. Presented to the Geological Department of the British Museum by Messrs. Ogilvy, Gillanders & Co.
Height=38 c.m. *Length* 17 c.m.

PLATE 4.—Internal view of the upper part of a lower valve from the Bay of Bengal (Mergui), belonging to the Indian Museum, Calcutta.
Height=34 c.m. *Length*=16 c.m.

PLATE 5.—A medium sized upper valve with shallow interior, from the Bay of Bengal (Mergui)—belonging to the Indian Museum, Calcutta.
Height=28 c.m. *Length*=15 c.m.

PLATE 6.—External view of the lower valve of previous specimen (Pl. 5) showing the laminæ of growth and adherent balani—belonging to the Indian Museum.

Height=28 c.m. *Length*=15 c.m.

Ostrea gryphoides, *var.* cuttackensis, *var. nov.*

PLATE 7.—Lower valve showing internal characters; from the Bay of Bengal (Cuttack coast); belonging to the Indian Museum, Calcutta.

Height=23 c.m. *Length*=15 c.m.

PLATE 8.—(A) An upper valve from the Bay of Bengal (Cuttack coast), belonging to the Indian Museum, Calcutta.

Height=17 c. m. *Length*=12 c.m.

(B) Example of the lower valve of a shortened form strongly resembling this variety. Obtained from the Clive Street excavations at Calcutta. Presented to the Geological Department of the British Museum by Messrs. Ogilvy, Gillanders & Co.

Height=21 c.m. *Length*=12 c.m.

NOTE.—The measurements of the specimens figured are given in centimetres.

SILURIAN FOSSILS FROM KASHMIR. BY F. R. COWPER REED, M.A., F.G.S. (With Plate 9.)

I.- INTRODUCTORY REMARKS.

The discovery of Silurian ['Upper Silurian'] fossils in Kashmir has been recently recorded by Mr. C. S. Middlemiss, and the four principal localities at which they were found have been described by him in his paper on the "Revision of the Silurian-Trias Sequence in Kashmir" (*Records, Geol. Surv. India,* Vol. XL, Part 3, 1910, pp. 213-216). In this paper a few provisional remarks on the fauna were made, but there was no attempt at the definite determination of species. The specimens collected have been submitted to me for identification, and the following lists and notes are the result of my detailed examination of them.

The fossils are mostly poor and generally fragmentary or imperfect, while their condition as either internal casts or external impressions increases the difficulty of making satisfactory determinations, though the examples of some of the species are numerous. But in many cases there can be no reasonable doubt of their identification or specific relations, particularly when English or European specimens in a similar state of preservation from Silurian beds are available for comparison. Only one new species can be recognised and defined, though it is possible that others exist amongst the doubtfully identified species.

II.—LISTS OF SPECIES.

(*a*) *Locality.*—Gudramer, Naubug Valley (lat. 33° 4′; long. 75° 27′)
Horizon.—(1) 11-7-09. *Specimens.*—K 12·565 to K12·574.

Orthoceras cf. *tenuiannulatum* McCoy.
Cyrtoceras sp.

Calymene cf. *Blumenbachi* (Brong.)
Acidaspis kashmirica sp. nov.
Illænus aff. *Macallumi* Salt.
Phacops? sp.
Primitia sp.
Beyrichia sp.
Orthis basalis Dalm. var.
,, *elegantula* Dalm.
,, *sowerbyana* Dav.
,, cf. *spitiensis* Reed.
,, aff. *Bouchardi* Dav.
Leptæna rhomboidalis Wilck.
Triplecia insularis Eichw.
Plectambonites aff. *papillosa* Reed.
Strophonella cf. *euglypha* (His.) ?
Strophomena antiquata (Sow.)?
Stropheodonta cf. *applanata* (Salt.)
Camarotœchia cf. *nucula* (Sow.)
Wilsonia cf. *Wilsoni* (Sow.) ?
Rhynchospira aff. *Bouchardi* (Dav.)
Atrypa marginalis Dalm. var.
Meristella or *Merista* sp.
Pholidops implicata Dav.
Crania ? sp.
Lindstrœmia cf. *bina* (Lonsd.)

(*b*)*Locality*.—Gugaldar, Harpatnar Valley (lat. 33°51′: long. 75°25′)
Horizon.—(1) 19-6-09. *Specimens*.—K12·575 to K12·578.

Calymene cf. *Blumenbachi* (Brong.)
Encrinurus cf. *punctatus* (Brünn.)
Acidaspis kashmirica sp. nov.
Orthis basalis Dalm. var.
,, *elegantula* Dalm.
,, cf. *crassa* Lindstr.
,, aff. *Bouchardi* Dav.
Plectambonites transversalis Dalm.
Merista ? sp.
Alveolites repens (Fougt.) ?
,, ? sp.

(*c*) *Locality*.—Lutherwan (camp), north-east side, Margan Pass (lat. 33°46′ : long. 75°35′).

Horizon.—(1) 22-7-09. *Specimens.*—K 12·580 to K. 12·583.

Calymene cf. *Blumenbachi* (Brong.)
Acidaspis kashmirica sp. nov.
Encrinurus sp.
Illœnus ? sp.
Orthis basalis Dalm. var.
,, *elegantula* Dalm.
,, *rustica* Sow.
,, aff. *Bouchardi* Dav.
Plectambonites transversalis (Dalm.)
Leptœna rhomboidalis (Wilck.)
Alveolites repens (Fougt.) ?

(*d*) *Locality.*—Under Margan Pass, S. W. side. (lat. 33°44′, long. 75°32′).

Horizon.—(1) 21-7-09. *Specimens.*—K 12·579.

Conchidium cf. *Knighti* (Sow.) ?
Orthis basalis Dalm. var.

III.—NOTES ON THE FOSSILS.

ACIDASPIS KASHMIRICA sp. nov. Pl. 9, figs. 1—3.

The pygidia of this species are generally in a very fair state of preservation and their characters are for the most part readily determinable. The middle shield doe · not show s'ich distinctive characters, and none of the examples are very perfect. The free cheek possesses well-marked features, and two specimens are moderately well preserved. The thorax is unknown.

D'agnos's.—Head-shield transversely semi-circular or semi-elliptical ; middle shield with anterior border somewhat flattened, rather broad, slightly arched forward.

Glabella parabolic, moderately convex ; median lobe subcylindrical, with bluntly truncate anterior end. Three pairs of lateral lobes present ; anterior pair very small, nodular, indistinctly separated from lateral angles of frontal lobe ; second lateral lobes oval, about one quarter the length of glabella, slightly oblique to axis ; basal lobes, larger, oval, about half as long again as second lobes, slightly oblique. Longitudinal median furrows subparallel, arched inwards inside second and basal lobes. Occipital ring rather narrow, rounded, separated off by strong straight nearly horizontal furrow,

Anterior wing of fixed cheek rounded, narrow, widening slightly behind. Ocular ridge? Eye situated far back. Posterior wing of fixed cheek large, but narrow, horizontally extended, about 1½ times basal width of glabella. Facial sutures with anterior branches subparallel (?); posterior branches running nearly parallel to posterior margin of head-shield, arched a little forward, but bending back sharply at extremity to cut posterior margin. Surface of head-shield coarsely granulated.

Free cheek triangular, with slightly sigmoidal outline to outer margin. Genal angle armed with short stout straight spine bent outwards at obtuse angle to lateral margin. General surface of cheek subconical, slightly elevated, sparsely tuberculated and finely granulated. Eye elevated, situated far back and at apex. Border of cheek rather broad, slightly rounded, increasing in width posteriorly with 9-10 small equidistant tubercles placed in the marginal furrow along its course. Margin of free-cheek armed with a fringe of 12-13 short stout spines of which the anterior 5-6 are directed upwards at right angles to plane of head-shield, but the others are horizontal; the posterior 4 or 5 spines are larger and stouter than the rest.

Pygidium transversely subquadrate, twice as wide as long; with 3 pairs of marginal spines, all parallel and directed straight back; anterior pair of spines very short, forming merely small teeth; second pair more than twice as long as pygidium, longer and stouter than the others; third pair about half or two-thirds as long as second pair; all spines equidistant. Axis short, subconical, bluntly truncate, about one-third width of pygidium, not reaching posterior margin; composed of 3 segments, but second and third segments obscurely separated; third segment very small and narrow. Lateral lobes flattened, horizontally extended, with ridge from first axial ring to large tubercle at base of each second marginal spine at level of second axial ring, and with smaller tubercle at base of each third spine.

Affinities.—The species is a small one, the best preserved pygidium only measuring about 4 mm. in width. There is a great resemblance in the pygidium to *A. deflexa* Lake,[1] particularly in the development of the marginal spines, but the tubercles at their bases sufficiently mark off the Kashmir species. The head-shield

[1] Lake, *Quart. Journ. Geol. Soc.* Vol. LII, 1896, p. 239, Pl. VII, fig. 7; Reed, Girvan Trilobites (*Palæont. Soc.*), Pt. 3, 1906, p. 113, Pl. XV, fig. 15.

also has many points of similarity, *e.g.*, the position of the eyes, direction of genal spine and shape and lobation of the glabella, but the vertical direction of the anterior marginal spines of the free cheek is an obvious distinction. *A. deflexa* is an Upper Llandovery species.

CALYMENE cf. BLUMENBACHI (Brong.) Pl. 9, figs. 4, 5.

Most of the specimens referable to *Calymene* are so imperfect that it is difficult to determine their specific characters, and it is possible that more than one species is present. But there are specimens from Gudramer, Gugaldar and Lutherwan which so closely resemble *C. Blumenbachi* that it is difficult to avoid the conclusion that this species is really represented. The poorness of the material, however, is unfortunate, rendering difficult the distinction of intrinsic characters from those due to accidents of preservation. Both head-shields and pygidia occur. The glabella generally possesses, so far as can be seen, the usual characters of *C. Blumenbachi*, but there is one specimen from Lutherwan which has a more elongate form of glabella narrowing anteriorly, so that the frontal lobe does not overhang so much at the sides; a similar shape is found in a specimen from Newlands, Girvan.[1]

The pygidia, which are always separate and unattached, are subquadrate, somewhat emarginate behind, show 5 or 6 distinct rings on the broad axis with 1 or 2 indistinct ones behind, and there are 5 complete furrowed pleuræ on the dependent lateral lobes not corresponding with the axial rings; the pleural furrows extend half the length of the pleuræ. In these characters *C. Blumenbachi* seems identical. None of the specimens are of large size, the head-shields averaging only 8-10 mm. in length and the pygidia about 10 mm. in breadth.

The specimen with the more elongate glabella has the following measurements:—Length of head-shield 10 mm.; length of glabella 7 mm.; width of glabella at base 6·5 mm.; width of glabella across frontal lobe 4·25 mm.

ILLÆNUS aff. MACALLUMI Salter.

There is one internal cast of a somewhat crushed and distorted head-shield of a species of *Illænus* from Gudramer and an external

[1] Reed, Girvan Trilobites (*Palæont. Soc.*), Pt. 3, 1906, p. 134, Pl. XVII, fig. 13.

impression of part of the left side of another head-shield from the same locality. Both probably belong to the same species. The internal cast has the front part broken and imperfect but shows more characters than the other. The head-shield was apparently semicircular or semioval, and convex. The glabella is short and broadly hour-glass-shaped, being contracted across the middle; in length it seems to have been about one-third that of the head-shield. The axial furrows are concave outwards, curving in strongly from the base forwards and then bending outwards to end about level with the front of the eyes; at the base of the glabella they seem to make an acute angle (45°—60°) with the posterior margin of the head-shield. The fixed cheeks are small and together with the large eye-lobes are decidedly swollen. The eye-lobes are situated at about their own length from the base of the head-shield. The facial sutures curve strongly inwards from the anterior lateral margins to the eyes, the backward convexity being marked: behind the eyes they run outwards, but are not here well exposed in the specimens The axial furrows have a small oval glandular expansion near their front ends, and where they meet the occipital furrow behind there is a deep pit. On the external impression of the head-shield there is a series of 10-12 strong equidistant terrace-lines running concentric to the anterior margin. A small median tubercle seems to be present near the base of the glabella.

Dimensions.

Length of head-shield	about	60 mm.
Width of ditto across eyes	„	50 mm
Width of glabella at base	„	40 mm.

Remarks.—The affinities of this species seems to be with members of the group *Bumastus*, especially with *I. Macallumi* Salter.[1] and *I. barriensis* Murchison.[2] The course of the axial furrows, the shape of the glabella, and the course of the facial sutures indicate this relationship; and while the size and position of the eyes more resemble the first mentioned species, the greater width and shortness of the glabella recall the second. But in dealing with such a crushed and imperfect specimen as is available a precise comparison is out of the question.

[1] Salter, Mon. Brit. Trilob. p. 210. Pl. XXVIII. fig 1: Pl XXX. figs. 2. 3.
[2] *Ibid.* p. 203, Pl. XXVII, figs. 1-5.

ENCRINURUS cf. PUNCATATUS (Brünnich).

There are two fragmentary pygidia and one free cheek from Gugaldar, and one free cheek and a body ring from Lutherwan in the collection which may be compared with *Encrinurus punctatus*. The pygidium is broadly triangular and seems relatively rather shorter than in *E. punctatus*; the axis, however, has the usual shape; the first few axial rings (3 or more) are complete, but the others (of which only 8 or 9 can be counted, the tip being missing) are incomplete in the middle, leaving a bare smooth median space on which are situated a few median tubercles, the first one being on the 5th, the second on the 7th and the third one on the 10th ring in the best preserved specimen. Another smaller specimen shows about eight pleuræ on the lateral lobes with the usual characters but the real number present is unknown.

The free cheeks which may be associated with this pygidium have the ordinary shape of *E. punctatus* with the anterior process well seen; the eye is elevated, rounded and conical with a contraction at the base, and the rounded convex border is remarkable for bearing a row of especially prominent large pointed tubercles projecting forward in the front.

The thoracic ring so far as it is preserved exhibits no points of difference from *E. punctatus*.

There is scarcely sufficiently known of this Kashmir form to state positively that it is identical with or only a variety of *E. punctatus*, but its characters so far as preserved show that it is closely comparable with it.

PHOLIDOPS IMPLICATA Sowerby ?

One small fragment from Gudramer shows the characteristic shape and concentric lamellation of this small brachiopod,[1] but the interior is unknown.

ORTHIS (DALMANELLA) BASALIS Dalman, var. Pl. 9, figs. 6—9.

Diagnosis.—Shell subcircular to subquadrate, bi-convex to plano-convex; cardinal angles rounded or obtuse; hinge line straight, less than width of shell.

[1] Davidson Mon. Brit. Brach. III, p. 80, Pl. VIII. figs. 13-17.; *id.* V. Silur. Suppl. p. 216, Pl. XVII, fig. 48.

Pedicle valve gently convex, slightly keeled in posterior part: beak small, pointed, rising above hinge-line, a little swollen and incurved; hinge-area triangular, vertical, or steeply inclined. Teeth forming strong plates, half the length of muscle-scar. Muscle-scar about one quarter the length of valve, subcordate in shape, widest in front, slightly emarginate behind, clearly defined, prolonged at lateral angles into a pair of slightly divergent straight narrow vascular grooves for less than half the length of shell.

Brachial valve flattened, with weak median longitudinal depression; beak small, not incurved or prominent; hinge-area very narrow or linear. Cardinal process not prominent, oval, weakly grooved in centre; walls of dental sockets strongly thickened and produced into stout short crura; low ridge from base of cardinal process continued forwards between the two pairs of adductor muscles.

Surface of valves covered with numerous fine subangular or rounded subequal ribs, numbering 80-100 on margins, curving slightly back on each side to cardinal angles where they become finer and more closely set; ribs divide at one quarter and again at one-half or two-thirds their length and occasionally again at three-fourths; primary, secondary and tertiary ribs and interspaces of equal or subequal size on margin. Shell-substance finely punctate.

Dimensions.

Average length 15 mm.
,, width 17 ,,

Remarks.—This is by far the most abundant species of brachiopod at the three localities, Gudramer, Gugaldar and Lutherwan, groups of half a dozen to a dozen individuals frequently occurring close together on the same block. It is practically indistinguishable from the shell from Falfield referred by Davidson[1] to Dalman's[2] species *O. basalis*, as a comparison with a large series of specimens from Falfield proves. Davidson did not describe the interior of the pedicle valve, but according to his figure and to numerous examples of the shell in the Sedgwick Museum the muscular scar is identical, though the divergent vascular grooves from the lateral angles are not apparent.

In this latter respect our Kashmir shell resembles the example of *O. canalis* McCoy, from Kilbride, as figured by Davidson[3] and also

[1] Davidson, *op. cit.* p. 217, Pl. XXVII, figs. 10, 11.
[2] Dalman, *Vet. Akad. Handl.* 1827, p. 116, Pl. II, fig. 5.
[3] Davidson, *op. cit.* p. 211, Pl. XXVIII, fig. 11 (excl. cet.).

O. lunata Sow.[1] The general characters, ribbing, etc., of our shell precisely agree with those of *O. basalis* from Falfield, and as there is a doubt whether Davidson's Falfield form is identical with Dalman's type, it is better to regard ours as a variety of this species for the above mentioned reasons.

ORTHIS (DALMANELLA) ELEGANTULA Dalman.

The shells which I have referred to this cosmopolitan and somewhat variable species differ from those of *O. basalis* var. by their more oval shape, by the greater convexity of the pedicle-valve and its more swollen incurved beak and higher hinge-area, by the brachial valve being sometimes depressed or slightly concave and never convex and by its median depression broadening towards the front and often bounded by low folds. The ribs also are less uniform in size, the intercalated ones being smaller, and there is no group of smaller ribs near the lateral angles. The shell-substance also seems to be more coarsely punctate. Though fragmentary specimens and internal casts are often difficult or impossible to distinguish, yet the sum total of differences is sufficient to separate the two forms specially, and the agreement of this type of shell with examples of *O. elegantula* from British Silurian beds is very close. It occurs at Gudramer, Gugaldar and Lutherwan but is less abundant than *O. basalis* var. and usually is smaller in size.

ORTHIS (DALMANELLA) cf. CRASSA Lindström.

There are a few specimens of *Orthis* occurring at Gugaldar which seem separable from the variety of *O. basalis* and to be comparable with *O. crassa* Lindström, as defined by Davidson.[2] The shell is subcircular to transversely elliptical in outline and the brachial valve is more convex than in *O. basalis* but has a weak median longitudinal depression. The crura are also stouter than in *O. basalis* and the cardinal process has a broader base. The muscular area in the brachial valve is oval and rather more than one-third the length of the valve; the posterior part is sunken and has raised edges, while the members of the posterior pair are separated by a broad low rounded ridge; the anterior pair of muscle scars is much fainter. The ribbing appears to agree with that described by Davidson in

[1] *Ibid.* Pl. XXVIII, figs. 4, 5.

[2] Davidson, *op. cit.* p. 213, Pl. XXVII, figs. 17-19.

O. crassa and to be finer and closer than that in *O. basalis* var. A submarginal internal thickening runs round the shell of the brachial valve. The pedicle-valve has not been positively recognised. The size of the shells varies from 12 to 15 mm. in length.

ORTHIS (PLECTORTHIS) cf. SPITIENSIS Reed.

Diagnosis.—Shell transversely semi-elliptical: hinge-line straight, equal to or rather less than width of shell: cardinal angles obtuse. Pedicle-valve moderately convex; hinge-area triangular, of moderate height, steeply inclined, with large triangular delthyrium; beak small, not swollen or prominent. Surface of valve with 12-18 strong coarse angular primary ribs, of equal or sub-equal size, arching a little outwards, and generally dividing into 2 or rarely 3 smaller similar ribs; occasionally 1 or 2 short ribs interpolated near margin. Interspaces angular, equal in size and depth to primary ribs. Ribs and interspaces crossed by strong regular equidistant concentric lamellæ.

Dimensions.

Length	. 12—15 mm.
Width	. 20—22 ,,

Remarks.—This species is probably identical with that termed *O. spitiensis* from Horizon 7 in Spiti and Kanaur.[1] There are only three examples of this Kashmir shell and all occur on one block from Gudramer; only one is well preserved as an external impression of the pedicle-valve. The relations of *O. spitiensis* have been discussed in the memoir referred to.

ORTHIS SOWERBYANA Davidson. Pl. 9, figs. 10, 11.

Diagnosis.—Shell biconvex, transversely semi-elliptical, widest along hinge-line. Hinge-line straight, equal to or slightly exceeding width of shell. Pedicle-valve rather more convex than brachial valve, somewhat flattened towards cardinal angles which are rectangular or slightly acute. Beak small (not well preserved). Surface of valve furnished with 40-50 simple rounded regular ribs of equal size and separated by rounded interspaces of equal width; towards cardinal angles the ribs are more crowded and interspaces narrower

[1] Reed, Ordov. Silur. Foss. Centr. Himalayas (*Palæont. Ind.*), p. 132, Pl. XIX, figs. 3-11. (In the press.)

and a few shorter smaller ribs arising at one-half to one-third the length of the primary ones are intercalated (occasionally one or more similar short ribs are intercalated in the median part of the shell); interspaces ornamented with fine concentric regular close striation. Brachial valve showing internal characters, dental sockets. cardinal process and muscle-scars as in *O. sowerbyana* Davidson.[1]

Dimensions.

	Pedicle valve.	Brachial valve.
Length	+15 mm.	15 mm.
Width	26 „	21 „

Remarks.—This form occurs at Gudramer and is rare, only 3 specimens having been recognised. It appears to be inseparable specifically from the Llandovery species *O. sowerbyana*, but it has not the smaller and shorter rib regularly interpolated between the primaries, as Davidson described. There is, however, considerable variation in the ribbing of *O. sowerbyana* from the Llandovery of South Wales, as the examination of a large series of specimens shows.

ORTHIS aff. BOUCHARDI Davidson. Pl. 9, figs. 12, 13.

There is an abundant small *Orthis*-like shell which occurs at Gudramer, Gugaldar and Lutherwan. Its interior is not satisfactorily known, but its external characters recall some species of *Scenidium*, though the hinge-area of the pedicle-valve is not so large as usual in that genus. The shell is transversely semi-elliptical, the width being usually from one and a half to twice the length; the hinge-line is straight and nearly equal to the width of the shell; the cardinal angles are rectangular or slightly obtuse. The pedicle-valve is strongly convex, slightly carinate, being most elevated down the median line; the beak is not much elevated or incurved, and the hinge-area is of moderate size. In the interior the muscle-scar seems to be subquadrate, about one-third the length of the shell, and the dental plates to be sub-parallel. The brachial valve is flattened with the lateral portions slightly convex and the middle third occupied by a shallow rounded but well marked median depression which widens rapidly anteriorly; the break is very small

[1] Davidson, Mon. Brit. Brach. Vol. III, p. 247, Pl. XXXV, figs. 27, 28, 30, 31 *non* 29).

and inconspicuous, scarcely rising at all above the hinge-line. There is no median internal septum; the walls of the dental sockets are thick.

The ribs are straight and radiating, but the lateral ones curve back a little towards the cardinal angles, particularly on each side of the sinus is the brachial valve. All the ribs are sub-angular to angular and rather coarse; there are usually about 15-20 primary ones of sub-equal size which divide into two or rarely three at about half or two-thirds their length, one branch usually remaining stronger than the others, or one or two short smaller ribs are intercalated near the margin. A concentric striation is often visible and the shell seems to be punctate.

The absence of an internal median septum, etc., in the brachial valve prevents us ascribing this little shell to *Scenidium Lewisi*[1] or one of its varieties as its exterior suggests, and it must be placed in the genus *Orthis* and is probably allied to *O. Bouchardi* Davidson.[2] The interior of the brachial valve seems identical with that of the form described by me[3] from Haverfordwest as allied to the latter species.

TRIPLECIA INSULARIS Eichwald. Pl. 9, fig. 14.

There is a good internal cast and external impression from Gudramer of a shell which may be referred without hesitation to *Triplecia insularis*. Its length is about 18 mm. and its width 27 mm. The typical shape and smooth exterior with the fold on the brachial and sinus on the opposite valve are well seen, and though the folds bounding the sinus are rather sharper than usual, this seems due to distortion and compression in the rock. The cardinal process, crura, teeth, etc., so far as can be seen, are the same as in *T. insularis*. This species does not appear to range above the Upper Llandovery in England, nor does the genus occur above the Clinton in America. Our shell much resembles the Girvan Upper Llandovery form figured by Davidson.[4]

STROPHOMENA ANTIQUATA Sowerby ? Pl. 9, fig. 15.

One imperfect internal cast of a pedicle-valve of a *Strophomena* from Gudramer may probably be referred to *Str. antiquata* (Sow.).[5]

[1] Davidson, *op. cit.* III, p. 208, Pl. XXVI, figs. 4-9.

[2] Davidson, *op. cit. III*, p. 209, Pl. XXVI, figs. 18-23.

[3] Reed, *Geological Magazine*, Dec. V, Vol. 2, 1905, p. 449, Pl. XXIII, fig. 8.

[4] Davidson, *op. cit.*, Vol. V, Silur. Suppl. p. 143, Pl. VIII, fig. 18.

[5] Davidson, *op. cit.* Vol. III, Pl. XLIV, figs. 2-13 (*non* figs. 21, 22).

The shell is subquadrate, very slightly convex; the hinge-line is rather less than the maximum width of the shell; the hinge-area is triangular, and inclined, with a small not incurved beak. The muscle-scar is as broad as long, rounded, subpentagonal, rather deeply sunk, with the sides bounded by thin curved edges, and the posterior end not enclosed; the diductors are separated by a low median ridge. The teeth are thin triangular plates continued anteriorly round the muscle-scar. The ribbing resembles that found in the variety *scabrosa* Davidson (*op. cit.* pl. XLIV, figs. 10, 11). Our shell is about 15 mm. wide and 11 mm. long.

PLECTAMBONITES TRANSVERSALIS Dalman?

This species is represented by a few broken internal casts and external impressions from Gugaldar in which we can recognise the characteristic muscle-scars, surface ornamentation and shape of the shell; and the identification is hardly doubtful.

PLECTAMBONITES aff. PAPILLOSA Reed. Pl. 9, fig. 16.

There is one small shell occurring at Gudramer which much resembles the Haverfordwest species of *Plectambonites* from the St. Martin's beds described by the author as *Pl. papillosa*.[1] In these Kashmir specimens the shell is transversely semi-elliptical, nearly twice as wide as long, with the cardinal angles nearly rectangular and not produced nor acutely pointed; the cardinal line is straight and equal to the maximum width of the shell. The pedicle-valve is very slightly and uniformly convex with a narrow triangular hinge-area and small inconspicuous beak, neither incurved nor swollen nor projecting. The brachial valve is flat. The surface of both valves is covered with closely set very fine straight radiating thread-like lines, of which generally every 4th or 5th one is rather stronger; and these stronger ones, numbering 20-30 on each valve, alone seem continuous from the beak to the margin. One interior of a pedicle-valve shows a pair of elongated narrow muscle-scars diverging from the beak at about 60°; the teeth are small and short and the interior of the shell is pustulate. The average length of our Kashmir shells is about 3 mm. and their width 5·5 to 6 mm.

[1] Reed, *Geological Magazine*, Dec. V, Vol. 2, 1905, p. 451, Pl. XXIII, figs. 13-15.

LEPTÆNA RHOMBOIDALIS Wilckens.

This cosmopolitan species is represented by a few poor but recognisable examples from Gudramer and Lutherwan, and they call for no particular remarks.

CAMAROTŒCHIA NUCULA (Sowerby)?

One external impression of a nearly perfect brachial valve of a small rhynchonelloid from Gudramer deserves special notice. The shell is transversely elliptical or subcircular in shape, measuring about 9 mm long and 11 or 12 in width; the surface is gently convex and there is a low median fold composed of 3 prominent, sharply angular equal plications increasing gradually in height and size towards the front; the interspaces are angular and equal to the plications is size, and the sides of the fold are steep and increase in height to the front; 4-5 similar angular plications, decreasing in size slightly to the cardinal angles, compose the lateral portions of the shell and fine concentric striæ cross ribs and interspaces alike. The lateral plications are not appreciably curved outwards. The characters of the shell agree with *Rh.* (*Cam.*) *nucula* Sow.[1] which varies somewhat, but has usually four plications on the fold. An internal cast from Gudramer of a brachial valve, however, shows four plications on the fold and the characteristic short median septum, etc., of *Rh. nucula*, and I do not think there need be any hesitation in referring this Kashmir form to this species.

CONCHIDIUM cf. KNIGHTI (Sowerby)?

The importance of the specimen on which this doubtful determination is based depends on the fact that it is the only indication of any other horizon than Llandovery and that there is only one other specimen from the locality "under Margan Pass," and this contains merely *O. basalis* var. The shell which may be compared with *Conch. Knighti*[2] consists of a brachial valve somewhat broken and distorted but showing the close narrow ribbing of the surface, the characteristic outline and apparently the median septum but

[1] Davidson, *op. cit.* Vol. III, p. 181, Pl XXIV, figs. 1-7; *ibid.*, Vol. V, Silur. Suppl. p. 157, Pl. X, figs. 27-29.

[2] Davidson, *op. cit.* Vol. III, p. 142, Pl. XVI, figs. 1-3; Pl. XVII, figs. 1-10; Pl. XIX, fig. 3.

the shell is so twisted out of shape that the septum scarcely seems to be in the middle. The ribs too are flatter and less angular than is usual in *C. Knighti*, but some American species of *Conchidium* have ribs like this Kashmir shell. Fragments of the other valve are preserved on the same hand-specimen in close association with the brachial valve, and one shows the umbonal region with part of the spondylium.

The brachial valve must have measured 25-30 mm. in length, so far as its broken condition permits an estimation of its original size.

RHYNCHOSPIRA aff. BOUCHARDI (Davidson)?

There are two imperfect external impressions of a small subcircular or oval terebratuliform shell which seems referable to the genus *Rhynchospira* and may be allied to *Rh. Bouchardi* Davidson.[1] The valve which is represented seems to be the pedicle one and is rather strongly convex with sloping shoulders meeting at the beak at about 75°-90°. A single median simple low rounded rib, twice as broad as the lateral ones, runs down the centre of the valve, and there are about 12 low rounded simple regular equal lateral ones on each side of it. The ribs are separated by narrower rounded grooves. There are some very imperfect casts of interiors, also from Gudramer, but no details can be satisfactorily made out. It is possible that this shell belongs to the genus *Zygospira*. Our shell measures about 10-12 mm. in length.

ATRYPA MARGINALIS Dalman, var.

There is one imperfect external impression of the greater part of the pedicle-valve of a subcircular or subpentagonal shell about 27 mm. wide having the general shape, ribbing and prominent beak of *Atrypa marginalis* Dalm., but it differs in some details. Thus the sinus seems to have a small median fold in it and it is not so abruptly bounded by sharp edges; the fasciculate ribs are also as strong in the sinus as on the lateral portions of the shell, which is unusual. However, *A. marginalis* is a variable form,[2] and ours may possibly be a new variety.

[1] Davidson, *op. cit.* Vol. III, p. 127, Pl. XII, figs. 26-30.

[2] Davidson, *op. cit.* Vol. III, p. 133, Pl. XV, figs. 1, 2, Lindström, Fragmenta Silurica, (1880), p. 22, t. XII, figs. 11-16.

MERISTA ? sp.

Several imperfect internal casts and external impressions of a small subcircular meristoid shell occur in the collection from Gudramer and Gugaldar. The shell is biconvex with a small sharp incurved beak to the pedicle-valve and traces of a false area on each side; the teeth are small, short and parallel and a short narrow triangular "shoe-lifter" process about one-third the length of the valve is also present. The brachial valve is rather less convex, and shows a median low rather thick septum extending about half the length of the valve. The exterior of the shell appears to be smooth. These small shells may belong to *Merista* and externally somewhat resemble those described by Lindström[1] as the young of *Meristella crassa*, Sowerby, or the shell called *Athyris ? compressa* Sowerby,[2] but the true generic position and relations cannot be satisfactorily decided with such poor material as is available.

ORTHOCERAS cf. TENUIANNULATUM McCoy. Pl. 9, figs. 17, 17*a*.

One internal cast of a species of *Orthoceras* occurs in the collection from Gudramer; it measures about 90 mm. in length with a maximum diameter of about 22 mm. The shell is half imbedded in matrix and is somewhat crushed. The rate of tapering is slow, being about 1 in 15. The shell is annulated regularly by equidistant rings, set nearly at right angles or very slightly oblique to the axis, and numbering 7 or 8 in a distance equal to the diameter; the rings themselves are narrow, rounded or sub-angular and prominent, and the shallow concave interspaces between them are about three times as wide. A series of fine thread-like raised parallel lines of equal size run longitudinally down the shell at equal distances and number 3-4 in a millimeter. No cross-section is visible, and the positions of the siphuncle and septa cannot be determined. The species with which this shell may be especially compared is *O. tenuiannulatum* McCoy[3] which Blake[4] describes from the Upper Llandovery as well as the Ludlow beds.

CYRTOCERAS sp.

A portion of a large *Cyrtoceras*-like shell from Gudramer is too imperfect and fragmentary for complete determination, for it only

[1] Lindström, Fragmenta Silurica (1880), p. 21, Pl XIII, figs. 4-8.

[2] Davidson, *op. cit.* III, p. 122. Pl. XII, figs. 16-18.

[3] McCoy., Syn. Brit. Palæz. Foss. Woodw. Mus. (1851), p. 320, pl. 14, figs. 31-31*a*.

[4] Blake, Mon. Brit. Foss. Cephal., (1882), p. 98, Pl. V. figs. 9, 9*a*.

consists of three cameræ and the siphuncle is not seen, nor is the curvature determinable. The shell is elliptical in section, the ratio of the axes being about 2 : 1, and the rate of increase in the longer diameter of the shell appears to be about 2 in 5 or 6, but the specimen is somewhat distorted by pressure, so that precise measurements cannot be obtained The septa are simple and not undulated, but lie slightly oblique to the axis of the portion preserved and become rather wider apart on the outer periphery; thus, on the outer periphery the three cameræ seem to occupy a space of about 20 mm., but on the inner curve only about 14 mm. The dimensions of the specimen are as follows:—longer diameter at upper end about 70 mm. shorter diameter about 40 mm. There are several British species to which this species seems allied in one respect or another, but it is too imperfectly known for any useful comparison.

IV.—AGE AND CORRELATION OF THE BEDS

The series of fossils from Gudramer, Gugaldar and Lutherwan agree in so many particulars and include so many species in common that it seems practically certain that the beds at these three localities from which the fossils were collected are on the same stratigraphical horizon. The faunas are practically identical in composition. and the state of preservation of the organisms and the petrological characters of the rocks agree most closely.

With regard to the age of this fauna, the evidence points towards the base of the Silurian, and it may be referred to some part of the Llandovery with considerable assurance. The presence of species allied to or identical with *Triplecia insularis*, *Orthis sowerbyana*, *Plectambonites papillosa*, *Lindstrœmia bina* and the affinities of *Acidaspis kashmirica* indicate a Llandovery rather than Wenlock age, while *Camarotœchia nucula* and *Orthoceras tenuiannulatum* are Llandovery as well as Ludlow species. Indeed it may be remarked that there is a suggestive resemblance in the group of brachiopods to those found at the very base of the Silurian in the Haverfordwest district.[1] But on the other hand Upper Llandovery types of trilobites are represented by the species of *Illænus* and *Acidaspis*. We cannot fail to note the absence of Pentameriads, though whether this

[1] Reed and Cantrill., *Geological Magazine*, Dec. V, Vol. IV, 1907, p. 535.

is real or apparent in the composition of the fauna is uncertain. As to affinities with Wenlock or higher beds there is no very convincing evidence, if we omit the long-ranging species; the absence of all the typical corals, crinoids and trilobites as well as of many of the characteristic brachiopods make a reference to a Wenlock horizon improbable. The variety of *O. basalis*, and the supposed *Wilsonia* and *Rhynchospira* are the only suggestions of post-Llandovery age. It is unlikely that we should be able to correlate with minute precision this Kashmir fossiliferous horizon with the far-distant shallow-water series in England; but we may go so far as to state that it may be referred with every probability to the Llandovery, using the term in a comprehensive sense.

The other locality in Kashmir which has yielded Silurian fossils is that "under Margan Pass," but the specimens are very few and poor. If the fossil referred with hesitation to *Conchidium knighti* is rightly determined an age corresponding with the Aymestry Limestone seems to be indicated.

EXPLANATION OF PLATE.

PLATE 9.

FIG. 1.—*Acidaspis kashmirica* sp. nov. Pygidium, (interior) ×5. Gudramer.
FIG. 2.— „ „ Middle-shield ×5. Gugaldar.
FIG. 3.— „ „ Free cheek, (interior) ×5. Gudramer.
FIG. 4.—*Calymene* cf. *Blumenbachi* (Brong.) Portion of middle-shield, (interior) ×3. Lutherwan.
FIG. 5.— „ Pygidium ×5. Gugaldar.
FIG. 6.—*Orthis* (*Dalmanella*) *basalis* (Dalm.) var. Pedicle-valve (internal ×2. Gudramer.
FIG. 7.—Ditto. Ditto. ×2. Gugaldar.
FIG. 8.—Ditto. Cardinal portion of brachial valve (internal cast) ×3. Gudramer.
FIG. 9.—Ditto. Pedicle-valve (impression of exterior) ×2. Lutherwan.
FIG. 10.—*Orthis sowerbyana*, Dav. Brachial valve (internal cast) ×2. Gudramer.
FIG. 11.—Ditto. Impression of part of exterior of valve ×2. Gudramer.
FIG. 12.—*Orthis* aff. *Bouchardi*, Dav. Pedicle-valve (internal cast) ×4. Gudramer.
FIG. 13.—Ditto. Brachial valve (internal cast) ×4. Gugaldar.
FIG. 14.—*Triplecia insularis* (Eichw.) Pedicle-valve ×1½. Gudramer.
FIG. 15.—*Strophomena antiquata* (Sow.) ? Pedicle-valve (internal cast) ×2. Gudramer.
FIG. 16.—*Plectambonites* aff. *papillosa*, Reed. Pedicle-valve (impression of exterior) ×5. Gudramer.
FIG. 17.—*Orthoceras* cf. *tenuiannulatum*, McCoy ×1½. Gudramer.
FIG. 17(*a*).—Ditto. Portion of surface of same specimen ×5.

NOTE ON SPECIMENS OF BLÖDITE[1] FROM THE SALT RANGE. BY CYRIL FOX, B.SC., M.I.M.E., F.G.S., *Assistant Superintendent, Geological Survey of India.* (With Plate 10.)

THESE specimens were obtained from the Mayo Salt Mines,[2] Khewra, Salt Range, Punjab, having been presented to the Director of the Geological Survey by Messrs. Lyon and Reid of the Northern India Salt Revenue Department, and consist of bright red masses of closely aggregated crystals of a flattish elongated habit. The mineral is almost colourless and transparent in itself and, but for the red inclusions of ferric oxide which give it its brick colour, it is completely soluble in distilled water. Its composition as determined in the Geological Survey laboratory by the late Mr. Blyth is that of a hydrous sulphate of sodium and magnesium plus a small quantity of chlorine.

Some of Dr. Warth's specimens from the same locality were examined by Mallet[3] who finds the composition of the blödite to be—

MgO	11.97	per cent.
Na_2O	18.53	"
SO_3	47.82	"
H_2O	21.54	"
NaCl	0.07	"

with a small unweighable quantity of lime and some material which is insoluble in water. Mallet appears to lean towards an interaction between Epsom salt and common salt (:—$2(MgSO_4, 7H_2O)+2NaCl = MgSO_4, Na_2 SO_4, 4H_2O+MgCl_2, 6H_2O+4H_2O$), as the probable sources and method of origin of the blödite in the kainite zones

[1] Also known as Warthite, Simonyite, and Astrakanite; Dict. of Names of Minerals, Chester, pp. 22, 34, and 250; *Tschermak's Min. und Petrogra. Mitth.*, XXII, (1903); Deutschlands Kalibergbau, (1907); Übersicht der Min. Petro. u. Geol. Kalisalz-Lagerstätten; Dana's System of Mineralogy. p. 946.

[2] *Mem. Geol. Surv. India*, XIV, pp. 28 and 285.

[3] *Mineral Mag.*, XI, (1879).

of the salt stratum.[1] It would appear possible that the impurities found in the analysis were, in all probability, carried by the underground waters which had leached out the blödite and deposited it in the fissures traversing the beds; the ferric oxide coming from the marls and the chlorine (as NaCl) from the wall of rock salt on which the crystals grew.

Quenstedt, Schimper, and Mallet have each made a crystallographic examination of blödite from the Mayo Mines and their determination of "faces" is summarized in fig. 1 (a hitherto unpublished drawing by Mallet). The new specimens are much simpler in general habit, but from one or other of the crystals practically all the forms depicted in fig. 1 have been noted, and although the faces μ (130), λ(310), and *f* (144) do not occur on them they exhibit the face *t* (311), I think for the first time on crystals of blödite from the Salt Range. The following is a list of the faces which have been observed on these new crystals:—

a (100),	*p* (111),
b (010),	*q* (201),
c (001),	*s* (211),
d (011),	*t* (311),
e (021),	*u* (111),
m (110),	*x* (121),
n (210).	*y* (221),
o (121),	γ (120).

Among the smaller crystals there appear to be two types of habit, one similar to fig. 2 and the other like that shown in fig. 3; the latter type is somewhat turbid in appearance and evidently grows to the larger size. As a whole the crystals are very fine and clean-cut, and much resemble those of Dr. Warth's from the same mine preserved in the Geological Museum in Calcutta[2]; they are red in colour through inclusions, larger in size, some quite 3½ inches in length, and show as many forms of face, and have a habit almost identical with the colourless crystals already in the Museum. Compare figs. 1 and 2, also those depicted in Groth's Chemische, Krystallographie II, p. 505, and that accompanying von Rath's paper.[3]

[1] Data of Geo-Chemistry, U. S. Geol. Surv., Bul. 330, pp. 176-9.
[2] Mineral Section, Show Case No. 30.
[3] *Poggend. Annal.*, pp. 586, CXLIV, (1871).

On days when the air is highly charged with moisture the crystals soon become coated with moisture when removed from the drying jar, though they dry quietly under an electric fan unless the air is almost saturated. Owing to their deliquescent nature the specimens are apt to become dull in damp weather and the edges and angles to lose their sharpness.

A faint pitting in broken lines parallel to the vertical axis is noticeable on those prism faces which have become dull. If etched, the corroding action of the acid or water is quite easily seen under the microscope, while if simply observed with an ordinary pocket lens the more deeply etched portions present an appearance much like the columnar structure of basalt.

Except for three very rough fractures parallel to the orthopinacoid, all the fractures observed are conchoidal. Other than rock-salt no associated mineral is present with the blödite.

EXPLANATION OF PLATE.

PLATE 10.

FIG. 1.—Blödite from the Salt Range (drawing by F. R. Mallet.)
FIG. 2.— Ditto.
FIG. 3.— Ditto,

REPORT ON CERTAIN GOLD-BEARING DEPOSITS OF MONG LONG, HSIPAW STATE, NORTHERN SHAN STATES, BURMA. BY J. COGGIN BROWN, M.SC., F.G.S., ASSOC. M.I.M.E., *Assistant Superintendent, Geological Survey of India.* (With Plates 11 to 13.)

INTRODUCTION.

THE Möng Lông sub-State forms the north-western part of Hsipaw proper and is bounded on the north and west by the Ruby Mines and Mandalay divisions, respectively. The greater part of the country comprised within its boundaries consists of lofty groups of hills which often attain heights of 4,000 or 5,000 feet above the level of the sea, and rising abruptly from the plateau overlook the flatter and less elevated regions to the south. The portion of the hilly country to which this report particularly refers, is very deeply dissected by the complex drainage system of the upper waters of the Nam-pai which eventually becomes the Chaung-Magyi and flows into the Irrawaddy, some twenty miles north of Mandalay. Extensive denudation is characteristic of the district and even the smallest tributary streams have excavated deep and narrow valleys generally possessing almost precipitous sides.

General Geology of Mong Long.

The researches of La Touche have already shown that a broad belt of mica schists occupies the valley of the Nam-pai, to the south of the gneissic area of the Ruby Mines division, and in which the town of Möng L ng, the capital of the sub-State, is situated. The rock consists of a rather fine grained biotite schist, but outcrops are difficult to find, "and all that can be seen in the few exposures visible along the paths are patches of micaceous clay in which the original foliation planes are marked by splashes and lines of bright scarlet, resulting from the oxidation of the iron in the rock."[1] These mica schists are very often traversed by quartz veins of various dimensions. Proceeding southwards

[1] "Geology of the Northern Shan States," by T. H. D La Touche (in the press).

from the Nam-pai valley towards the Shan plateau, the mica schists give place to a series of quartzites, greywackes, slates, phyllitic shales, and sandstones which belong to the Chaung-Magyi series. There is no definite boundary between this series and the mica schists and one type of rock appears to pass into the other. Rocks of the Chaung-Magyi series make up the whole of the area under description, the prevalent types being hard greyish and brownish quartzites, and fine-grained, dark greenish-grey, chloritic slates. The general strike is N.-N.-W—S.-S.-E., and the strata are greatly contorted. The Chaung-Magyi rocks form the floor on which the succeeding fossiliferous formations of the Northern Shan States have been deposited; they are of pre-Cambrian age and may correspond with the Hu-t'o system of Central and Western China. The country is exceedingly broken, and consists of numberless narrow valleys, separated by high, steep-sided ridges, which are always covered from top to bottom with almost impenetrable jungle; so that the only way of making any examination is to wade along the stream beds,—though even here a path has often to be hacked through the thick growth,—or to follow the narrow paths which occasionally proceed along the knife-edged spurs from one remote village to another.

Area Examined.

The particular part of the Möng Lông sub-State which it was my duty to examine is situated in the Pazi township about long. 96° 30′ and between lats. 22° 38′ and 22° 42′. Over this area a license to prospect for gold has been granted to the Sawbwa of Hsipaw. The survey pillar marked 4,223 is at the top of the area, which is bounded on the east by the Hwe-gna-sang chaung as far as its junction with the Nam-e-wa; on the south by the Nam-e-wa; on the west from the junction of the Hwe-hkam-long with the Nam-e-wa, along the valley to pillar 4,223; on the north by a line from the survey pillar to the Hwe-gna-sang chaung. Small amounts of gold have been washed in a desultory fashion from the alluvial gravels of these and neighbouring streams for a great number of years by both Burmese and Shans.

Description of Route to Hwe-gna-sang.

Marching N.-N.-W. from Hsumhsai, a station 22 miles beyond Maymyo on the Shan States branch of the Burma Railways, in the

direction of Kalagwe, long. 96° 33′, lat. 22° 31′, approximately, a perfect example of the true "plateau" type of country of the Northern Shan States is crossed. As far as the eye can reach, flat uplands modified here and there by gentle undulations. with smooth rounded outlines are seen. Thick growths of coarse grasses and the common bracken fern (*Pteris Aquilina*), form a general covering, but patches of scattered trees or open scrub jungle are by no means uncommon. The soil is of a dull Indian-red tint and water is very scarce, owing doubtless to underground circulation. Exposures of the plateau limestone are few and far between, and when seen, either outcrop in jagged hummocks which rise a few feet above the general level of the surrounding country, or occur near the waterholes where percolation and seepage have removed the superincumbent soil and exposed the surface of the rock below.

From Kalagwe the route continues for some four miles in a N.-W. direction across similar plateau country in which outcrops become more frequent than before, and are seen to consist of the usual type of greyish limestone in a profoundly brecciated condition. This persists to one and-a-half miles N.-N.-W. of Nahka. when just before the Chaung Kaung stream is reached, and on the steep bank of a small tributary, typical Naungkangyi marls of yellowish, reddish and reddish-brown shades are found outcropping. A search soon reveals the presence of small crinoid stems, and the jumble of fragmentary and indeterminable remains of trilobites. cystideans, and brachiopods, so characteristic of this Ordovician series. In the bed of the stream, hard greyish-blue limestones are found, representing the unaltered Naungkangyi strata. Before the Chaung Kaung is reached, small exposures of Plateau Limestone are again met with. These are little outliers which lie unconformably on the older rocks beneath. for on crossing the stream and ascending the hill on the other side, Naungkangyi marls of similar type continue, and at an elevation of 2,900 feet above sea level contain a thin band of hard greyish-blue limestone with thin. irregular, yellowish-brown joint planes and patches in which sections of brachiopod shells can be made out. There is a slight descent in the surface of the plateau between Kalagwe with an elevation of 3,200 feet, and the Kaung Chaung at 2,500. From this point the hills bordering the plateau abruptly rise, the track keeping on a spur between two side tributary valleys evenly clad with open forest growth. Beyond the Naungkangyi beds, the Chaung Magyi rocks

are found, and continue right through the defined area. They usually occur as grey, greyish-white and brownish quartzites, discoloured mudstones, bleached purple slates, greenish phyllitic slates and finely banded, hard, schistose shales of various colours. They form very steep hill sides covered with small fragments of the harder strata. The quartzites weather into sharp, angular blocks, but on the whole, exposures are poor up to the top of the range which is reached at 3,800 feet. From this point there is a winding and very steep descent to the Nam-e-wa, (2,350 feet), on which soft, discoloured schistose-slates of various shades of grey, buff and greyish-blue are seen a few times, often with red ferruginous stains. Their general strike appears to be N.-N.-W.—S.-S.-E. and they often contain tiny empty squares left by decomposed pyrites crystals. Thin veinlets and disconnected stringers of quartz are common everywhere. and small veins of milk-white quartz up to one and-a-half feet across are occasionally found.

Mode of Occurrence of the Gold.

The gold from the Hwe-gna-sang and its tributary streams occurs in thin laminæ and scales, generally rough and somewhat elongated with rounded edges. Flattened pieces over $\frac{1}{4}$ inch in length have been obtained but the vast majority of the scales range from $\frac{1}{16}$ to $\frac{1}{8}$ inch along their greatest length. A certain proportion of a bulk sample consists of smaller rounded grains, but very fine and "float" gold is absent. Associated with these are a number of grains, which bear no appearance of flattening, which have a very irregular surface and are generally of a darker colour than the flattened scales. These are regarded as "ultra" nuggets which have not been carried far from their matrix in comparison with the rest of the gold, and are consequently not worn. Very rarely small particles of gold were found adhering to quartz,—which led to the testing of the veins which were found. Spinels, garnets and magnetite are the principal constituent minerals of the concentrates after treatment of the gravel for the gold. Several small rounded "nuggets" with a very irregular pitted surface have been obtained from the Hwe-gna-sang gravels, ranging up to $\frac{3}{8}$ inch long by $\frac{1}{4}$ inch broad by $\frac{1}{8}$ inch in thickness approximately. Although there can be no doubt that a certain small proportion of the gold has been derived from auriferous quartz reefs of the Chaung Magyi rocks outcropping in the area drained by the streams,

yet the physical condition of by far the greater part of it, together with the negative results of the assays of the few reefs which were sampled, seems to point to its derivation from the quartzitic and schistose rocks themselves, whence it was probably introduced during the time of their deposition from some outside source,—perchance from the great area of crystalline rocks to the north. Gold is found in most of the streams which drain the Chaung-Magyi rocks of this region of Hsipaw and which make up the greater parts of Sheets 240 and 286 Burma Survey. It is interesting to note that La Touche has proved that the alluvial gold of the Loi Twang region of the Northern Shan State originates from a series of sandstones which are found below the Naungkangyi beds of that area.[1] A very similar occurrence has been observed by myself in the Yunnan Province of Western China where gold is won from rocks which have probably the same age. The gold of the Namma alluvials may also be cited as a further instance of the same kind. In view of these facts, the attention of prospectors may be drawn to other streams which drain areas made up of the same rocks, which have not yet received the attention they deserve.

Shan Methods of Obtaining Gold.

After extracting the gravel from narrow pits sunk into the terraces in any places which appear likely to yield well, the Shans obtain the gold by a system of panning in a batea, in the manipulation of which they obtain remarkable skill. The batea itself is usually about 1 foot 8 or 9 inches in diameter, cut out of a solid piece of cedar and shaped to form a very depressed cone, after the fashion of the Mexican pan. After drying, the wood is lacquered with a jet black varnish which gives a perfectly smooth surface on which the gold is easily observed. Recently a modified form of " cradle " or " rocker " has been introduced to expedite the ordinary method of panning. Two branches bearing a V at their upper ends are driven into the ground about 3 feet a part and 4½ feet above the surface. To the middle of another branch laid across the V's a lattice-work bamboo basket holding about ¼ of a cubic foot of gravel is tied. The gold-saving table is placed

[1] "Report on the Gold-bearing Deposits of Loi Twang, Shan States, Burma. By T. D. La Touche, B.A., F.G.S. *Records Geol. Surv. India*, Vol. XXXV, Part 2, 1907, page 104.

under the basket and is arranged so as to catch anything which comes through. It varies from 1 to 2½ feet in breadth but is always 4 feet or more in length. The first 6 inches are smooth, and the rest of the table is riffled by alternate straight cuts, ½ inch in breadth and ¼ inch in depth with corresponding projections. The table is given sufficient slope to cause the stream of water used to carry away most of the lighter washed material. The whole apparatus is usually set up in the shallows at the edge of a stream, where the auriferous gravel is loaded into the basket, which is kept gently rocking while a stream of water from a scoop is allowed to flow over it. The smaller pebbles and sand go through on to the table which is now and then washed down directly, and the larger stones thrown away. The operation is repeated until 8 or 10 cubic feet have been washed, when the contents of the riffles are carefully transferred to a batea and panned in the usual way. With a gravel free from clay and containing no fine gold this method appears to be fairly effective in recovering the precious metal, but its capacity is only about 1 cubic yard of gravel per man, per day; without reckoning the labour employed in digging out the pay dirt and keeping the pit drained, it cannot be regarded as a very economical device. The machine is not a Shan invention, but a foreign introduction, for I have seen a very similar apparatus in use on the upper parts of the Yang-tze-chiang on the borders of Yunnan and Szu-chuan. All the sampling which I undertook was carried on by pits from which measured quantities of gravel were extracted and washed under my personal supervision. This was the only available method, though open to objection in some cases owing to the amount of water in the gravels. At the same time I believe the results are accurate enough to warrant the conclusions which I have drawn.

Results of Assays.

The results of the examination of the concentrates in the laboratory of the Geological Survey of India in Calcutta have proved to be very disappointing in view of the reported quantities of gold obtained by the Shan workers. I am inclined to believe that they know, after long years of work, where the rich streaks of pay dirt are likely to exist in the main mass of gravel and are so able to collect comparatively large amounts of coarse gold at the expense

of a minimum amount of labour. The average gold content of the gravels is given in the table at the end of this report. Even if the gold content had been much higher than it actually is, I should not have been able to recommend large-scale modern exploitation, owing to the smallness and patchy nature of the gold-bearing ground.

STREAMS EXAMINED.

The Hwe-som-kuan.[1]

This stream, which only has a length of 2 or 3 miles, is a tributary of the Hwe-hkam-long and rises from a small side valley in the main ridge of the concession about $1\frac{1}{4}$ miles to the south of Loi sar (Δ4,223). It flows in a general S.-S.-W. direction to join the Hwe-hkam-long about $\frac{3}{4}$ of a mile above the junction of the latter stream with the Nam-e-wa. From the village of Hto-hei, a steep track runs down into the valley of the Hwe-som-kuan to the S.-W. The stream is merely a shallow mountain torrent which has eroded a narrow V-shaped valley for itself, cutting across the strike of the strata. At the time of my visit it contained very little water. Geological observations were considerably hampered by the thick jungle which fills the whole valley and cannot be penetrated without cutting a path. Thin deposits of gravel of very limited extent appear to have been deposited by the flood stream in places where the bed rock has allowed the accumulation to take place, but these are buried as a rule under a great deal of scree material from the steep sides of the valley and under thick soil. Again, these gravel patches have been very extensively worked in ancient times and wherever they exist numerous old pits bear silent testimony to the energy with which they have been exploited.

Under my direction, three pits were sunk in places which did not appear to have been much disturbed. No. 1 passed through 8 feet of wet earth, containing large angular rock fragments, without reaching gravel, but the influx of water at this depth became so great that further excavation was impossible. Nos. 2 and 3 reached gravel, with a thickness of 2 and 3 feet, at 6 and 4 feet, respectively. The former yielded a trace of gold per cubic yard and the latter contained no gold.

[1] "Som-kuan" (Shan) is the name of a small shrub common throughout the Shan tates, the leaves of which are prepared and eaten by the people as a sour condiment.

Other gravel patches in this ravine might yield better results but I hardly believe that extensive prospecting is warranted here. Large masses of quartz were seen in places, which, doubtless, come from a vein or veins somewhere in the locality, but exploring for quartz reefs under the thick jungle and soil-cover would be very expensive work.

The Hwe-pung.[1]

This stream rises in or near Loi sar (Δ4,223), and flowing at first S.-S.-E. and then E.-S.-E., with a length of course of about 2 miles, joins the Hwe-mi-pang to become the principal feeder of the Hwe-gna-sang. It is a larger and faster flowing stream than the Hwe-som-kuan and has a broader and better marked valley, though as usual this is overgrown with dense jungle. The bed rock is exposed most of the way along the valley, but here and there patches of gravel of no great extent are to be found. There is evidence here, as in some of the other streams, of a former higher depositing level, for many of the ancient pits are sunk into shallow deposits high above the level of the present stream, but jungle growth is so thick that it is almost impossible to tell how much of these are true alluvial deposits and how much may have been formed by scree and the debris of denudation from the surrounding hill sides. These patches of gravel have been worked over exceedingly well in ancient times, and old pits abound wherever gravel exists. The stream is a transverse one and the rocks exposed in its bed are of a sandier nature than usual. A small pit in the bed of the present stream had recently been opened and displayed a section of 2 feet of soil with over 6 feet of gravel full of big stones. The gravel yielded 7·578 grains of gold per cubic yard, but the deposit was of very limited extent, being a mere pocket in the surrounding rock.

The Hwe-hkam-long.[2]

This stream rises on the western flanks of Loi sar and flows in an approximately southerly direction to join the Nam-e-wa. It has a well marked but thickly jungle-covered valley, and its lower reaches contain numbers of old pits sunk into a shallow gravel deposit above the present level of the stream, which is about the same

[1] Hwe-pung (Shan)=" Valley of bees."
[2] Hwe-hkam-long (Shan)=" Great golden valley."

size as the Hwe-pung. It is noteworthy that there are no pits above its junction with the Hwe-po-la. The gravel deposits are of very limited extent and shallow. No prospecting was done on them.

The Hwe-mi-pang, Hwe-um-na and Hwe-hin-tap.

These streams are small mountain torrents and, according to the few Shanized Palaungs who are the sole inhabitants of this neighbourhood, contain neither gravel deposits nor old workings and were not therefore visited.

The Hwe-gna-sang.[1]

This stream contains the most extensive and richest gravels of the area examined. It does not contain a large volume of water and, for a certain part of its course, it flows through a narrow gorge with high rock-bound sides, but above and below this are more open places where deposition has taken place. Above Kung-to the Hwe-gna-sang divides into two streams :—

(*a*), the Hwe-pung rising in or near Loi sar (Δ 4,223), and flowing S.-S.-E. and then E.-S.-E. to where it joins,—

(*b*), the Hwe-mi-pang coming from the north, length of course about 1½ miles, and,—

(*c*), the Hwe-um-na, flowing at first west and then S.-W. and joining the other two streams (*a*) and (*b*), just below their confluence, after it has itself been joined by the Hwe-ma-chi-nu from the S.-E. The highest gravel area which I examined is situated at Kung-wo, and is some two miles as the crow flies, though nearer 4 by the stream, from the Sawbwa's camp at Hwe-gna-sang. Here in a small embayment of the main valley, surrounded on all sides by high forest-covered spurs, about 1½ acres of gold-bearing gravel under an average of 6 feet of overburden exist, with possibly half as much again under scree and terrace overburden from 20 to 35 feet thick. Small amounts of gold are said to have been obtained from thin bands in this upper terrace formation. A considerable amount of washing with the "cradle," I have described in a previous paragraph, has been carried on here and a long trench has been cut exposing

[1] **Hwe-gna-sang (Shan) = "Valley of the Elephant's tusk."**

the gravel for about 100 yards. This showed the folling section:—

2 feet soil.
4 feet upper earthy gravel with sand.
4 feet lower coarse gravel.

The bottom layer alone contained the gold which in my own tests averaged as high as 9·687 grains per cubic yard. Quartz boulders of very large dimensions were common, but water was not troublesome. Future operations have been complicated owing to the overburden from the present workings having been banked up on unworked ground.

The largest areas of gravel were found between the lower end of the gorge and the junction of the Hwe-gna-sang with the Nam-e-wa. The valley opens out a little just below the gorge, and here 3 acres of gravel were found beneath an overburden from 5 to 6 feet thick.

Two pits were sunk in this deposit, the sections exposed being as follows:—

Pit No. 1—

3 feet soil.
1½ feet clay.
1 foot fine gravel with some carbonaceous matter.
6 feet coarse gravel, containing large boulders.

The upper gravel yielded 2·442 grains of gold per cubic yard, and the lower gravel 3·424 grains per cubic yard.

Pit No. 2—

2 feet soil.
1 foot upper brackish gravel.
6 feet lower coarse gravel with some clay.

One cubic yard of the upper gravel was found to contain 1·302 grains of gold, and a similar amount of the lower gravel yielded 5·324 grains of gold. In both pits the bed rock was encountered and found to be a soft decomposed blue phyllite. The greater part of this area is under dense grass jungle.

This upper area is separated from the lower one, which I designate the Hwe-gna-sang camp deposit, by a narrowing of the main valley. Gravel appears to exist in an irregular thin deposit on one side of the stream, but it is under overburden from 14 to 20

feet thick, and is therefore not considered worth working by the Shans. The Hwe-gna-sang camp area is met with where the valley broadens out again, and contains the largest gravel deposit of the district, covering about 6½ acres approximately. The plan attached to this report shows the disposition of some of the pits which have been recently opened up.

Pit No. 1 showed—

5 feet soil.
4 feet gravel.

The bed rock was reached, but a considerable influx of water necessitated the use of a bamboo pump, the pit being situated at the stream level. The gravel contained a larger number of pebbles than usual and one very large quartz boulder was encountered. One cubic yard of this gravel contained ·452 grains of gold.

Pit No. 2—

4 feet soil.
1½ feet upper gravel.
2 feet soft bluish sandy mud.

The influx of water then became so great that further excavation could not be carried on.

One cubic yard of the upper gravel gave 2·76 grains of gold, and a cubic foot of the sandy mud when washed yielded three fine colours.

Pit No. 3—

3 feet soil.
3 feet upper gravel with clay.
3 feet lower gravel with many large stones.

The influx of water was not great in this pit and the bed rock was met with. One cubic yard of the gravel contains 2·864 grains of gold.

Pit No. 4—

5½ feet soil.
4 feet upper gravel.

Further work was prevented by water. One cubic yard of the upper gravel gave 3·924 grains of gold.

Pit No. 5—

3½ feet soil.
2½ feet gravel with numerous quartz boulders.

One cubic yard of the upper gravel yielded 7·635 grains of gold.

Pits Nos. 6 and 7—

These pits were close together and showed the same section:—

2 feet soil.

$3\frac{1}{2}$ feet gravel with large stones and clay bands.

An unusually large quantity of iron ores was found in the concentrate, but the gold content only averaged 1·603 grains. The lower parts of the gravel deposit seemed to be absent in these pits, the bed rock here as elsewhere being the same soft, decomposed chloritic slate, with an occasional well marked phyllitic structure.

Between the head of the Hwe-gna-sang ravine and Kung-wo there are one or two little embayments where small quantities of gravel have been deposited. The first of these has an extent of about one acre. A pit sunk in the middle of this deposit touched a coarse pebble bed overlain by a thin band of cemented gravel less than 1 foot thick, at 13 feet. Pan tests on the gravel gave less than 1 grain of gold per cubic yard.

The second area examined between the head of the ravine and Kung-wo is known by the name of Ha-seik and is about $1\frac{4}{5}$ acre in extent. Two pits were sunk here and exposed:—

Pit No. 1—

$2\frac{1}{4}$ feet soil.

2 feet upper gravel, with a hard band of black cemented material.

2 feet lower gravel, finer than the above, but full of water, and containing large quartz boulders.

The upper gravel contained no gold, and the lower gravel 2·52 grains per cubic yard.

Pit No. 2—

3 feet soil.

3 feet coarse gravel with big stones.

This gravel yielded ·93 grains of gold per cubic yard. The third area examined (known as Pang-ngu-lin) lies between the head of the ravine and Kung-wo, has an extent of from $1\frac{1}{2}$ to 2 acres and contains some old test pits. The overburden appears to have an average thickness of about 8 feet, but the earthy, ferruginous gravel found below it yielded no gold in the test I was able to make,

High Level Terraces on the Hwe-gna-sang.

Both the areas on the Hwe-gna-sang, which I have called the upper and the camp deposits, lying below the ravine, are bounded by narrow higher terraces, the remains of which are generally seen in small embayments of the main valley. There are four of these altogether, two in the camp area and two in the upper area. They vary in extent from ½ to 1 acre approximately. Old pits are often found near the junction of the older with the newer deposits, the reason for this being that the ground is drier and easier to work through here. Gold is not won from them at the present day though one pit has been sunk through the terrace formation in the upper part of the camp area. Here I found a thin band of earthy gravel lying above the bed-rock and covered by more than 20 feet of overburden.

Another pit further down stream also showed a thin gravel band under 25 feet of overburden. This gravel yielded 1·587 grains of gold per cubic yard.

Nam-e-wa.—Tests were made on the little gravel banks in the bed of the Nam-e-wa near its junction with the Hwe-gna-sang but no gold was found.

Examination of Quartz Reefs.

Three large quartz reefs situated, (1) near the village of Hto-hei, (2) in a small tributary stream ½ mile above the Sawbwa's camp, Hwe-gna-sang, (3) ½ mile up the Nam-e-wa beyond its confluence with the Hwe-gna-sang, were sampled. To clear away the adjacent rock and to obtain representative samples, dynamite had to be resorted to. The assay of the samples in the laboratory of the Geological Survey of India in Calcutta has shown that the samples contain no gold.

Summary of Results.

The general results of my examination of the gold bearing alluvial deposits of this district is given in the annexed table, from which it will be seen that the areas situated on the Hwe-gna-sang are the only ones which need be taken into consideration here. Small patches of gold-bearing gravel certainly occur in some of the other streams, but they are of very limited extent. The Kung-wo deposit contains an average of 9·687 grains of gold per cubic yard, but its

small area and great inaccessibility preclude the possibility of the introduction of modern methods of any kind.

The little areas of Ha-seik and other deposits above the ravine carry a smaller quantity of gold and also have the same disadvantages as the Kung-wo deposit. The Hwe-gna-sang deposit is made up of 9½ acres (upper reach 3 acres, lower reach 6½ acres), and contains an average of 3·185 grains per cubic yard in both upper and lower gravels ; moreover the distribution of the gold is exceedingly capricious. The total value of the gold present here would only pay a small part of the cost of a dredge and its transportation to, and erection on, the ground, were other conditions favourable, which is far from being the case. For the same reason I am unable to recommend the adoption of any hydraulicing process, for the construction of the necessary ditches and flumes would cost more than the value of the deposit allows of, especially in an area where the topographical conditions are not suitable for such work. The gravels may well be left to be worked by the Shans in the manner in which they are now being exploited, though I would advise the abandonment of the "rocker" at present in use and the substitution of some form of "tom" in its place. The latter machine is well fitted for the locality owing to the coarseness of the gold, and it would treat from twice to three times the amount of gravel in the same time at the same cost for labour. In conclusion I would point out that the larger streams of this and surrounding districts are worthy of an examination and that there are greater chances of larger areas of payable alluvial deposits with a more even distribution of gold being discovered in such stream-beds, than in small tributaries which often have a rapid current and are usually little more than mountain torrents.

EXPLANATION OF PLATES.

PLATE 11.—Shans washing auriferous gravel at Hwe-gna-sang.

PLATE 12.—Plan of Hwe-gna-sang auriferous deposit.

PLATE 13.—Map showing Hwe-gna-sang concession.

Table showing distribution and area of auriferous gravels.

Sub-State.	Name of stream.	Approximate area of deposit.	No. of Pit.	Thickness of overburden.	Thickness of gravel.	Character of deposit.	Proportion of stones over 1½" in diameter.	Amount of gold per cubic yard.	REMARKS.
		Acres.		Feet.	Feet.		%	Grain.	
Möng Long	Hwe-som-kuan	..	1	8	..	..	..	..	
			2	6	2	Earthy gravel	..	Trace	Excavation stopped by water.
			3	4	3	" "	..	*Nil.*	
	Hwe-pung	..	1	2	6	Gravel with big stones.	50	7·578	Small pocket deposit.
	Kung-wo	1½	1	6	4	Clean coarse gravel	20	9·087	Four feet of overburden consists of non-auriferous gravel. Large quartz boulders common.
			2	6	3	" "	20		
		¾	..	20—35	..	..	..	..	
	Upper-area (Hwe-gna-sang)	3	1	4½	7	Gravel with large boulders.	..	2·933	Upper 1 foot finer gravel=2·442 grains per cubic yard. Lower 6 feet coarser gravel =3·424 grains per cubic yard.
			2	2	7	Coarse gravel with clay.	20	3·313	Upper 1 foot gravel=1·302 grains per cubic yard. Lower 6 feet gravel=5·324 grains per cubic yard.
	Camp area (Hwe-gna-sang)	6½	1	5	4	Gravel with many pebbles.	..	·452	..
			2	4	3½	Thin gravel band above sandy mud.	..	2·76	From upper 1½ feet of gravel.
			3	3	6	Gravel with clay and stones.	..	2·864	..
			4	5½	4	Coarse gravel	..	3·924	..
			5	3½	2¼	Coarse gravel with quartz boulders.	..	7·635	..
			6, 7	2	3½	Gravel with stones and clay.	..	1·603	Unusually large iron ore concentrate.
	1st area, between ravine and Kung-wo.	1 approximately.	1	13	¼	Cemented gravel band.	..	Under 1	..
	2nd area, Ha-seik	1½	1	2½	4	Coarse gravel with big boulders.	30	2·52	Upper 2 feet cemented gravel has no gold.
			2	3	3	Coarse gravel	..	·93	..
	3rd area, Pang-ngu-lin.	1½—2	1	8	2	Earthy ferruginous gravel.	25	*Nil*	..
	Camp area, upper terrace.	¾	1	25	2	Earthy gravel	20	1·587	..

NOTE ON STEATITE DEPOSITS, IDAR STATE. BY C. S. MIDDLEMISS, *Superintendent, Geological Survey of India.* (With Plates 14 to 16.)

THIS note is to put on record a discovery of large stores of steatite made during 1911-12 field-season. The larger of the deposits occurs in the hilly area between the scattered Bhil villages of Dev Mori and Kundol (position of the outcrop being lat. 23° 39′ to lat. 23° 40′, long. 73° 28′), sheet No. 146 Bombay, 1″-1-mile survey. The bed runs in an almost exactly N—S direction following two north and south flowing longitudinal stream-beds and crossing the low little " pass " between them. On each side the parallel ridges are composed of quartzite (Hacket's Delhi quartzite ?) whose strike is definite and dip obscure and varying, but generally steep. The line of the steatite outcrop is believed to be a sharply folded anticline near the little " pass " just 100 yards south of which runs section I. Half a mile N. of this in the little elliptical hollow in the hills the anticline splays out showing a dip of 40°E in its eastern limb, by a well section and in the hills to N. N. E. of the well (see section II).

Owing to obscuring soil and talus from the quartzite hills, exposures are partial but fairly numerous. Across the best of these the two sections have been drawn, the details being augmented by a number of shallow pits which I had sunk (2 to 6 feet in depth) to prove the outcrop where hidden. Up to date the estimates arrived at are length of bed over 1 mile, width over 200 feet with practically vertical dip. Section II, near the northern end of the outcrop, will require deep pits to determine the condition obtaining at the centre of the anticlinal there. Over 200 feet have been shown by pits on the western side with vertical dip and about 10 feet are exposed in the well, 210 yards distant to east, with a dip of 40°E. The pits excavated between these positions showed hard kankar and calcareous tufa at from 3 to 5 feet below the surface. From the great quantity of fragments scattered all over the elliptical hollow in the hills and lying on the soil and alluvium, I think it probable that the steatite will be found nearly throughout the section.

Where actual boundaries to the steatite deposit are seen, the bounding rock is a bright green, amphibole-calcite rock, with at some localities magnesite (breunerite) serpentine rock passing into talcose rock. Other varieties are deep green actinolite-quartz rock which passes up into quartzite. Asbestos of very good quality also occurs.

The steatite over the sections sampled is apparently fairly uniform in composition, finely schistose or cleaved, and of pale blue grey to pinkish grey colour by reflected light. It is moderately hard, free from foreign minerals, and readily cuts up with a saw into slabs and pencils. The latter take a good point and on slate or black-board yield a clean, even, white line of good brilliance. It may be said to be of very fair quality, but so far as present surface outcrops show, is not of first-class quality suitable for the finer trade requirements.

There are indications in surface pieces picked up of a still softer, more cream-coloured variety in small amount. From similar indication there are also harder and darker grey rocks and some dark green (doubtless mixed with chlorite) rock of still harder character that would carve into durable ornaments.

Calculating on the 200 feet basis for thickness, over a length of one mile, to a surface depth of only 20 feet, there appears to be over 2 million tons within sight and within easy reach.

A smaller occurrence of somewhat similar steatite has also been found ¼ mile N. W. of the deserted village of Ghánta (lat. 23° 36′—long. 73° 26). Three or four closely connected beds of about 10 feet thickness, each, are exposed for about 30 yards in the stream-bed, partially obscured by kankar. The surrounding alluvium hides any possible extension of the outcrop along the valley. The mineral does not appear among the solid strata of the hills to north and south. This outcrop is only separated by a few miles from the one described above, and the two are probably connected underground.

EXPLANATION OF PLATES.

PLATE 14.—Plan of Steatite occurrence, Idar State.

PLATE 15.—Section No. 1.

PLATE 16.—Section No 2.

MISCELLANEOUS NOTES.

Supposed Eruption of a Mud Volcano in the Straits of Cheduba, Arakan Coast, Burma.

Scattered through the earlier volumes of the Records of the Geological Survey of India are numerous accounts, chiefly from the pen of F. R. Mallet, of eruptions of the mud volcanoes of Ramri and Cheduba Islands off the Arakan Coast of Lower Burma. In a more recent paper[1] I have recorded, as far as possible, similar disturbances which have taken place since then, and have shown that not only do these eruptions take place on the Islands themselves from the "volcanoes," which often lie dormant for long periods, but that they also occur far out to sea, and occasionally succeed in raising large islands of mud. These have been known to exist long after the actual eruption is over, until in fact, the soft material of which they are composed is removed by the denuding action of currents and waves. A reference to this paper will also show that instances are known in which the eruption has not had sufficient force to raise the ejected material above the surface of the sea, and the disturbance is only made known by the violent ebullition caused by liberated gases, or by actual shallowing of the water as shown by soundings.

The eruption which I propose to record here belongs to this latter class. I am indebted to Captain A. G. Abbott, Commander of the *Malda*, and to Messrs. Bulloch Brothers, Agents of the British India Steam Navigation Company in Rangoon, for the details of the occurrence from which the following account is made up.

It appears that on the 13th of April 1911, the S.S. *Malda* was proceeding on a voyage from Kyaukphyu to Sandoway, and whilst steaming down the Straits of Cheduba at 12 knots the ship suddenly stopped. We not only have the evidence of Captain Abbott and of the Chief Officer of the S.S. *Malda*, but also that of Commander Horden of the Royal Indian Marine Service, that the ship was on

[1] "Mud volcanoes of the Arakan Coast, Burma," by J. Coggin Brown, *Rec. Geol. Sur. India*, Vol. XXXVII, Pt. 3.

her proper course, and following the usual track between the two ports. The true bearings when the vessel was aground were Button Island, north 62° east, centre of Round Island, south 30° east, Bare Hill north 22° west. The steamer took the mud at 6-30, the depth of water at the bow being 9 feet and at the stern 12 feet, whilst she was drawing 17 feet of water aft. A sounding with the hand lead immediately before the grounding gave 5½ fathoms of water. The ship appears to have been firmly embedded in the mud, as she did not rise in the slightest degree, whilst the lead when used sank into a moving mass of mud, so that in the words of Captain Abbott, "the more line you gave the lead the deeper it sank". The water on the port quarter appears to have gradually deepened so that when the vessel was put full speed astern at 7-25, she immediately came off the mud, and having been backed for 5 cables, was anchored in 7 fathoms of water until daylight next morning, when cross bearing observations showed that she was still on the proper track.

Captain Abbott did not then think it wise to continue his voyage through the Straits and he proceeded to Sandoway by going around Cheduba Islands. There appears to be little doubt that the cause of the vessel's grounding was the raising of the sea bottom by the accumulation of a mass of soft but viscous mud, the product of the eruption of a submarine mud volcano. It is to be regretted that we have no observations of the state of the sea at the time, though it seems possible that there might be little or no evolution of gas if the actual eruption was over.

Messrs. Bulloch Brothers have informed me through the Port Officer in Akyab that, up to the middle of June last, the commanders of their three mail steamers at present employed on the Arakan Coast were unaware of any further disturbances caused by mud volcanoes.

In most parts of the world, where geological conditions have favoured the formation and accumulation of petroleum, mud volcanoes with their associated phenomena exist. It is not often, however, that the geographical conditions necessary for submarine eruptions occur, though gas explosions have been reported from the Caspian Sea and off the coasts of the oil-bearing regions of Trinidad, Mexica and California.

It may not be out of place to quote here descriptions of the submarine gas explosions of the Caspian Sea, as a comparison

with the similar observed instances of the Burmese Coast. "Marvin describes one spot in the sea off Bibi-Eibat[1], between Baieloff and Shikoff promontories, where the petroleum gases reached the surface in such volumes that the violent ebullition set up had sufficient force to capsize boats that passed over the place. The same traveller also mentioned that if a light were applied to some parts of the sea in Baku Bay on a calm day, acres of water were covered with flame; but these effects are no longer visible, due perhaps, to the active exploitation of the Bibi-Eibat oil field, with which the outcrops are in communication. Gas still however escapes in such volumes from the bed of the Caspian Sea, in a few places, that the surface is violently agitated, rendering the spots visible from a long distance on a calm day; but it is stated by old observers that these phenomena are decreasing in extent as the active exploitation on the shore proceeds. One of the attractions of Baku to curious sight-seers is to witness the sea on fire, either of Bailloff Point or near the coast of Holy Island, for which steam yachts may be hired or borrowed to convey visitors to the locality. On a calm night the disturbed spots are readily discernible, and when a piece of lighted tow is flung into the gas, ignition takes place, and the gas burns fiercely, scorching the paint on the sides of the vessel if allowed to approach too near. If the wind is not too high, the gas continues to burn for days, but in a high breeze and rough sea the flame is blown to one side and extinguished."[2]

[J. COGGIN BROWN.]

Selenite in the Jhansi District, United Provinces.

When selenite was reported as found in the Hamirpur District (See account thereof in Rec. Geol. Sur. India, XXXVII, p. 282) my attention was called to the fact by the Chief Secretary of these Provinces who suggested that possibly it might also be found in the Jhansi district. I accordingly instituted inquiries with the result that I learnt that it was found in the villages of Gonti and Gokal in the northern part of Tahsil Garotha; while the "Gajar Mathi" which in Hamirpur is said to be associated with the finding of

[1] The Bibi-Eibat Oil Field is situated 3 miles to the south of Baku on the Western shore of the Caspian Sea in Southern Russia.
[2] "The Oil Fields of Russia," by A. Beeby Thompson, page 101,

selenite, was reported as existing in the villages of Dhanora, Kakarbai, Parsua and Siya[1] (all of which are in the neighbourhood of Gokal) though there is no record of the actual finding of selenite in any of these four. All these villages are in the north-east corner of the district, *i.e.*, part nearest to that part of the Hamirpur district in which selenite is found.

In February 1910 I was able to visit the place in Gokhal where the selenite is found. It lies about one mile S. W. of the village in the ravines along the Bira Nala in obviously just such a manner as is described by Mr. LaTouche. The "Gajar Mathi" with which it is associated is a peculiar friable yellow clay, which in the dry season cracks in every direction into small pieces, varying in size from little over a quarter inch across at the surface to large blocks up to 6 or 8 inches across at a depth of a foot or so where it is moister. So friable is it that there is no difficulty in excavating a hole a foot or more deep into the sloping side of the ravine with the hands or a stick. In the rainy season this soil forms slush into which a man will sink a foot or more. It is always singularly barren growing scarcely any of even the coarsest grasses that cover most of this ravine country elsewhere in the wet season. The selenite crystals are found scattered in this clay; but are mostly gathered at the end of the rains when they have been washed out and either left on the surface of the ravine or else deposited in the stream bed below.

The occurrence in Gonti village is situated 2¾ miles east of the inhabited site and a little less than a mile S. W. of that of Malehta (long. 79° 15′; lat. 25° 48′) at a place called the "Usraithi Bank" in the ravines of the Gararyao Nala. The crystals are found during and after the rains washed out of the bank. I have not been able to visit this spot, but from the account I have received thereof it appears to be very similar to that at Gokal.

I had a couple of pounds of crystals collected at each locality (the price is one anna per seer in the village where it is found) and sent them to the Allahabad Exhibition. The description given by Mr. LaTouche of the Hamirpur selenite applies to that found here. The crystals from Gonti were cleaner and brighter looking than those from Gokal.

[1] I give the positions of the villages named:—Dhanora long. 79° 20′; lat. 25° 43′; Gokhal 79° 19′, 25° 47′; Gonti 79° 12′, 25° 47′; Kakarbai 79° 23′, 25° 42′; Parsua 79° 17′, 25° 40′; Siyia 79° 20′, 25° 40′.

The local name is "usraith," the word "jharsonth" is not frequently used. The only use that I can hear of was for pounding up and conversion into "whitewash" but I fancy most is exported and the real uses are not known locally, the business of the finders ending with sale to the *baniya.*

[C. A. Silberrad, I.C.S., B.A., B.Sc.,

Collector, Jhansi.]

RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

Part 2.] 1912. **[July.**

GENERAL REPORT OF THE GEOLOGICAL SURVEY OF INDIA FOR THE YEAR 1911. BY H. H. HAYDEN, C.I.E., F.G.S., *Director.*

CONTENTS.

DISPOSITION LIST.

1. During the period under report the officers of the Department were employed as follows :—

Superintendents.

MR. C. S. MIDDLEMISS . .	Returned to head-quarters on the 16th April 1911. Granted privilege leave for 3 months with effect from the 9th May 1911. Returned from leave on the 7th August 1911. Placed in charge of the Bombay, Central India and Rajputana party. Left for the field on the 18th November 1911.
MR. E. VREDENBURG . .	At head-quarters as Palæontologist till 13th October 1911. Granted privilege leave for 1 month and 13 days and study leave for 4 months and 29 days with effect from the 14th October 1911.
DR. L. L. FERMOR . . .	Deputed from the 22nd March to 22nd April 1911 to examine the copper-lodes of Sikkim. Placed in charge of the Central Provinces party and left for the field on the 28th October 1911.

Assistant Superintendents.

MR. P. N. DATTA .	Returned from the field on the 5th May 1911. Granted privilege leave for 6 weeks with effect from the 10th October 1911. Returned from leave on the 21st November 1911. Posted to the Burma party and left for the field on the 12th December 1911.

DR. G. E. PILGRIM . . .	Returned to head-quarters on the 20th April 1911. Granted privilege leave for 3 months, study leave for 3 months and 20 days, and furlough for 3 months with effect from the 15th May 1911.
MR. G. H. TIPPER . . .	Returned from the examination of the samarskite deposits in Nellore, Madras, on the 26th February 1911. Acted as Curator till the 13th October 1911, and appointed Palæontologist from the 14th October 1911.
MR. H. WALKER . . .	Granted privilege leave for 2 months and 22 days and furlough on medical certificate for 3 months and 8 days with effect from the 20th January 1911. Returned from leave on the 17th July 1911. Posted to the Central Provinces party and left for the field on the 16th November 1911.
MR. E. H. PASCOE . . .	Returned to head-quarters on the 24th April 1911. Granted privilege leave for 3 months and study leave for 6 months and 9 days with effect from the 15th May 1911.
MR. K. A. K. HALLOWES	Returned to head-quarters on the 21st May 1911. Posted to the Burma party and left for the field on the 7th November 1911.
MR. G. DE P. COTTER .	Returned from leave on the 20th April 1911. Appointed Geological Officer, Oil-fields Advisory Board, Yenangyaung; left head-quarters on the 22nd September 1911.

MR. J. COGGIN BROWN . .	Returned from leave on the 7th March 1911. Deputed to examine and report on the gold-bearing gravels in Möng Lông State, Northern Shan States, and left for the field on the 28th April 1911. Assumed duties of Geological Officer, Oil-fields Advisory Board, Yenangyaung on the 13th May 1911. Returned to head-quarters on the 5th October 1911. Appointed Curator from the 14th October to 13th November 1911. Deputed to accompany the Abor Expeditionary Force and left head-quarters on the 13th November 1911.
MR. J. J. A. PAGE . . .	Returned from the field on the 5th March 1911. Granted special leave for 3 months and 2 days with effect from the 7th July 1911. Returned from leave on the 9th October 1911. Deputed to Mergui and Tavoy to advise on the wolfram and tin-mining industries of Lower Burma and left for the field on the 17th November 1911.
MR. H. C. JONES . . .	Returned to head-quarters on the 17th May 1911. Granted privilege leave for 2 months and 28 days with effect from the 30th June 1911. Returned from leave on the 9th October 1911. Re-posted to Central India for continuation of the survey of Gwalior State and left for the field on the 14th November 1911.

MR. A. M. HERON . . . Returned from the field on the 9th May 1911. Granted privilege leave for 2 months and 28 days from the 30th June 1911. Returned from leave on the 9th October 1911. Re-posted to the Bombay, Central India and Rajputana party and left for the field on the 25th October 1911.

MR. M. STUART . . . Returned from leave on the 12th February 1911. Services temporarily transferred (from the 18th February 1911) to the Madras Educational Department to act as Professor of Geology at the Presidency College, Madras.

MR. N. D. DARU . . . Granted privilege leave for 35 days from the 3rd January to 6th February 1911. Re-posted to the Bombay, Central India and Rajputana party for the survey of Dungarpur State and left for the field on the 23rd February 1911. Returned to head-quarters on the 11th May 1911. Deputed to the College of Science, Poona, as Lecturer on Geology from the 1st June to 30th September 1911. Re-posted to the Bombay, Central India and Rajputana party and left for the field on the 18th October 1911.

MR. H. S. BION . . . Joined the Department on the 28th February 1911. Appointed Curator on the 14th November 1911.

MR. C. S. FOX . . .	Joined the Department on the 2nd March 1911. Posted to the Central Provinces party and left for the field on the 15th October 1911.

Chemist.

DR. W. A. K. CHRISTIE . .	Returned from leave on the 8th January 1911. Deputed to Sambhar from the 26th February to 14th March 1911 in connection with the investigation of Sambhar lake brines. At head-quarters for the rest of the period under report.

Sub-Assistants.

S. SETHU RAMA RAU . .	Returned to head-quarters on the 18th May 1911. Attached to the Burma party and left for the field on the 27th October 1911.
M. VINAYAK RAO . .	Returned from the field on the 20th May 1911. Attached to the Central Provinces party and left for the field on the 25th November 1911.

Field Collector.

BANKIM BIHARI GUPTA . .	Appointed on the 17th July 1911. Attached to the Central Provinces party and left for the field on the 2nd December 1911.

ADMINISTRATIVE CHANGES.

2. The following officers joined the Department during the period under report:—

New officers. Mr. H. S. Bion, B.Sc. (London), F.G.S., joined on the 28th February 1911.

Mr. C. S. Fox, B.Sc. (Birmingham), M.I.M.E., F.G.S., joined on 2nd March 1911.

Appointments. 3. Mr. G. H. Tipper was appointed Palæontologist with effect from the 14th October 1911, *vice* Mr. E. Vredenburg on leave.

Mr. J. Coggin Brown was appointed to act as Curator from the 14th October to 13th November 1911, when he was relieved by Mr. H. S. Bion.

Promotion. 4. Mr. G. H. Tipper, Assistant Superintendent, Geological Survey of India, was appointed to officiate as Superintendent with effect from the 14th October 1911, *vice* Mr. E. Vredenburg on combined leave.

Leave. 5. Mr. C. S. Middlemiss was granted 3 months' privilege leave with effect from the 9th May 1911.

Mr. E. Vredenburg was granted privilege leave for 1 month and 13 days and study leave for 4 months and 29 days with effect from the 14th October 1911.

Mr. P. N. Datta was granted privilege leave for 6 weeks with effect from the 10th October 1911.

Dr. G. E. Pilgrim was granted privilege leave for 3 months, study leave for 3 months and 20 days, and furlough for 3 months with effect from the 15th May 1911.

Mr. H. Walker was granted privilege leave for 2 months and 22 days and furlough on medical certificate for 3 months and 8 days with effect from the 20th January 1911.

Mr. E. H. Pascoe was granted privilege leave for 3 months and study leave for 6 months and 9 days with effect from the 15th May 1911.

Mr. J. J. A. Page was granted special leave for 3 months and 2 days with effect from the 7th July 1911.

Mr. H. C. Jones was granted privilege leave for 2 months and 28 days with effect from the 30th June 1911.

Mr. A. M. Heron was granted privilege leave for 2 months and 28 days with effect from the 30th June 1911.

Mr. N. D. Daru was granted privilege leave for 35 days with effect from the 3rd January 1911.

OBITUARY.

6. The Geological Survey has lost a valuable coadjutor by the death of Dr. Victor Uhlig, who during the course of a large number of years had devoted himself to the study of the fossils of the Spiti shales. The results of his work have appeared in the *Palæontologia Indica,* and in my previous report I was able to write that the final part had been received from the author. Dr. Uhlig's knowledge of the fauna of the Spiti shales was unrivalled, and his loss will be severely felt.

7. The sudden death of Mr. T. R. Blyth, Assistant Curator, on March 21st has already been referred to in the previous volume of these *Records.* The lapse of time only emphasizes the value of his services and the difficulty of adequately replacing him.

STUDENTS.

8. Sayad Abdul Karim, B.A., of Hyderabad State, was under training until July 12th, when his course was completed and he was allowed to return to his State. During the early part of the year he was attached to the Central India party and worked in Bharatpur State.

UNIVERSITY LECTURES.

9. Mr. Vredenburg continued to hold the post of Lecturer on Geology at the Presidency College, Calcutta, until October 14th, when he took leave. He was succeeded by Mr. H. S. Bion.

10. The services of Mr. Murray Stuart were transferred to the Government of Madras on February 18th, when he took up the appointment of Professor of Geology at the Presidency College, Madras.

11. Mr. N. D. Daru acted as Lecturer on Geology at the College of Science, Poona, from June 1st until September 30th.

PUBLICATIONS.

12. The publications issued during the year comprise one volume of *Records,* two of *Memoirs,* and two memoirs of *Palæontologia Indica.*

LIBRARY.

13. The additions to the library during the year 1911 amounted to 3,107 volumes, of which 1,187 were acquired by purchase and 1,920 by presentation and exchange.

OFFICE.

14. The considerable increase of work during recent years made it necessary to apply to Government for an increase in the subordinate staff generally; this was sanctioned during the year, with the result that additions have now been made to the clerical staff, as well as to that of the Drawing Office and of the Museum.

DRAWING OFFICE.

15. After a service of thirty years, of which twenty had been spent in the post of Artist to the Geological Survey, Mr. H. B. W. Garrick retired on November 19th, 1911. The present high standard of the illustrations of our publications is due largely to Mr. Garrick's zeal and efficiency, whilst the conscientious and painstaking way in which he carried out his work invariably earned for him high praise from his official superiors. The loss of his services will be severely felt.

16. The new edition of the geological map of India (1″=32 miles) was completed during the year and 100 copies prepared. Most of these have already been disposed of, but a few have been reserved for sale.

MUSEUM AND LABORATORY.

Staff.

17. Mr. G. H. Tipper was Curator of the Museum and Laboratory until the middle of October, when Mr. J. Coggin Brown was appointed. When the latter left to join the Abor Expeditionary Force early in November, Mr. H. S. Bion took over charge. Mr. T. R. Blyth, Assistant Curator, died on the 21st of March. His loss is very severely felt. Babu Durga Sankar Bhattacharji was appointed on probation as Museum Assistant for Mineralogy and Petrology. Babu Bankim Bihari Gupta having been promoted to Field Collector, M. R. Ry. A. S. Subba Iyer, B.A., was appointed on probation in his place.

Determinative and chemical work.

18. The number of specimens sent to the Laboratory for examination and report was 325; of these assays and analyses were made of 44.

Fossils.

19. Mr. Tipper examined a very interesting collection of Jurassic fossils collected near Shekh Budin by Mr. Copeland, I.C.S., Deputy Commissioner of Dera Ismail Khan. Although collected without reference to stratigraphy, they are quite sufficient to prove the occurrence amongst the Jurassic beds of the Trans-Indus Salt Range of a liassic fauna comparable in every respect with that so well developed in Baluchistan. More recently fossils sent by the same collector have been received, which have been collected entirely from the lias. They include—

Harpoceras 2 sp.
Pecten sp.
Lima sp.
Thracia sp. and others which are specifically identical with Baluchistan forms.

Meteorites.

20. During the year there were three acquisitions to the meteorite collection, all of falls which took place in the previous year. Further portions of the Banda and Bilaspur aerolites were received and in addition two small fragments of the Indore meteorite, which fell on the 24th of November 1910 at the village of Lakangaon, in the pergana of Bhikangaon, Nimar district, Indore State. This fall was unrepresented in the collection until the Indore Durbar were kind enough to present these specimens.

Museum.

21. The work of re-labelling and re-arranging the rock collections is almost complete. The Siwalik gallery is now provided with printed labels. The re-arrangement of the invertebrate fossil gallery has been taken in hand and satisfactory progress made. A copy of the new edition of the geological map of India (1″=32 miles) has been mounted, framed, and placed in the Meteorite gallery.

Other Museums and Colleges.

22. On his way back to head-quarters at the end of the field-season 1910-11, Dr. G. E. Pilgrim visited the Lahore Museum at the request of the Curator and arranged and labelled a large collection of rocks and Siwalik fossils.

23. Mr. D. N. Wadia, Professor of Geology, Prince of Wales' College, Jammu, was given facilities for undertaking petrographical

and other research in the Laboratory for about two months during the monsoon.

MINERALOGY AND PETROLOGY.

24. Mr. Fox has measured, and described in the preceding part of this volume of the *Records*, some crystals of red bloedite from the Mayo Mine in the Salt Range. Except in colour, they differ but little from previously known crystals of the same mineral from other parts of the Salt Range; they show a face, however, *t* (311), not hitherto observed on any of these.

25. Mr. Tipper continued his examination of the monazite-bearing sands of Travancore, and, in addition, has been able to detect the presence of this mineral in small quantities in very widely separated localities. It has been proved to occur in small quantities in the sands near Tinnevelly and also in the cemented dunes of that district, in the Vizagapatam district, in concentrates from the Sabarmati river at Golwara in Idar State, and recently in tin concentrates from Southern Burma. Thanks to the kindness of Mr. H. P. Herbert, Manager, Morgan Crucible Company's Mines in Travancore, and Mr. E. Masillamani, State Geologist, specimens of the monazite-bearing pegmatites of that State have been carefully examined. The monazite is undoubtedly a primary accessory mineral, but, like many other accessory minerals, it does not follow any particular order in crystallization. Some of these pegmatites are very rich in monazite. In spite of this, the conclusion to be drawn from a study of the sands is that the bulk of the mineral is derived, not from the pegmatites, but from the denudation of the charnockites and granulites in which the monazite probably occurs in small quantities.

26. During the course of his survey of Idar State, Mr. Middlemiss met with a rock of unusual type and one of considerable interest. It occurs as a band at the junction of the Idar biotite granite with the Kawa dyke of olivine-dolerite (gabbro) at one mile north-west of Kawa. Microscopically it is a coarse, dark and light rock, with large poikilitic patches of biotite. It is composed of a fairly large amount of orthoclase, occasionally porphyritic as in the Idar granite, abundant lath-shaped plagioclase (albite-oligoclase) and quartz, a considerable amount of pyroxene in rather small idiomorphic and hypidiomorphic grains, often gathered together into clusters and showing here and there change to uralitic hornblende, a

large amount of biotite in great ophitic plates and, as accessories, iron ores and rather much apatite. Mr. Middlemiss regards this rock as a composite or "hybrid" one, due to chemical reactions between the two rocks now found on either side of it, *viz.*, the Idar granite and the younger intrusive Kawa dyke of olivine-dolerite. He concludes that owing to the basifying of the granite consequent on this intrusion, the quartz and orthoclase of the former have remained unaltered, but all the usually dominant microcline has disappeared, its place being taken by abundant plagioclase (albite-oligoclase); at the same time both the biotite and apatite of the granite have been largely reinforced. Or, regarding the reaction from the point of view of the basic rock, the more basic plagioclase (labradorite) has disappeared, as also has the olivine, whilst the pyroxene has persisted in more or less patchy groups. Except on the supposition of a commingling of material and chemical re-arrangement having taken place, it is difficult to classify a rock of such abnormal mineral constitution among the ordinary igneous rocks, and Mr. Middlemiss considers that all the conditions of its occurrence point to its being a hybrid.

27. During a course of study leave spent at Cambridge, Mr. Pascoe made a detailed examination of the lavas from Mount Popa in Upper Burma, and was able to confirm the conclusions of previous observers that these consist exclusively of andesites. He recognises two types, one a hornblende-andesite in which the hornblende phenocrysts show strong absorption borders and much alteration to magnetite, and the other a porphyritic augite-andesite with small rounded grains of olivine.

PALÆONTOLOGY.

Lamellibranchs and gastropods from the Spiti shales.

28. Amongst the collections from the Spiti shales sent to the late Dr. Victor Uhlig for description, there were a number of lamellibranchs and a few gastropods; these were handed over by Dr. Uhlig to Dr. Karl Holdhaus, whose description of the material has now been received and will shortly be published in the *Palæontologia Indica.* Dr. Holdhaus states that his examination of the bivalves tends generally to confirm the conclusions already arrived at by Dr. Uhlig from his study of the ammonites. At the same time the fauna seems to represent a very special and individualised facies, since, with the exception of certain species of *Astarte*, Dr. Holdhaus has

been unable amongst 37 species to find a single one that is truly identical with similar species from other regions; he has thus unfortunately been compelled to create a number of new species and one new genus. The gastropods are few in number, poorly preserved, and of no particular importance.

Himalayan Ordovician and Silurian fossils.

29. A very important work on Himalayan palæontology has just been completed by Mr. Cowper Reed, namely, the description of the Ordovician and Silurian fossils of Spiti and Kumaun. The material described includes Salter's duplicates of Strachey's original collections, Stoliczka's collections from Spiti, Griesbach's from Kumaun, Krafft's and mine from Spiti and Bashahr, and various small collections made by Messrs. Hughes, La Touche and others. Mr. Cowper Reed has been able to recognise definitely both Ordovician and Silurian faunas, of which the most remarkable feature is the striking American stamp of the Ordovician. Thirty-four species are closely related to American forms, but "while the affinities of so many species is remarkably close, yet scarcely any or perhaps even none are absolutely identical"; Mr. Reed attributes this to "a certain amount of modification having taken place in the course of their long migration from America." Equally remarkable is the absence from the Ordovician fauna of any European affinities, a fact which is the more striking in view of the very marked European character of the Ordovician of the Northern Shan States. The Silurian fauna on the other hand, although showing distinct American affinities in the corals, is on the whole rather European, although the strong European facies found in the Shan States is not developed.

Triassic fossils from Kashmir.

30. Dr. Diener has completed, for publication in the *Palæontologia Indica*, a description of the collections of Triassic fossils made by Mr. Middlemiss in Kashmir during the last few years. Amongst these Dr. Diener recognises representatives of the Lower Trias, Muschelkalk, and carnic stage of the Upper Trias. The lowest horizon of the Lower Trias, which is found at Pastannah, corresponds fairly closely with the Otoceras zone of Spiti and Kumaun. The genus *Otoceras*, however, has not been found in it, but *Ophiceras* and *Xenodiscus* predominate. An interesting feature of this fauna is the close connection that has been proved between these two last-named genera, the intermediate forms being comprised among Mr. Middlemiss' specimens. The lamellibranchs, however, are more

important than the cephalopods, and include large numbers of *Pseudomonotis* (*Claraia*), of which four species are particularly interesting as representing isolated elements of Mediterranean origin, but all leading forms of the Werfen beds of the Alps. A younger Lower Triassic fauna containing *Flemingites* and *Meekoceras* is attributed to the Hedenstrœmia stage of Spiti and Kumaun. A fairly rich fauna was obtained from this horizon in the Guryul ravine, and a similar collection from Mandakpal. The marked resemblance between the Lower Trias of Kashmir and that of Spiti and Kumaun is in decided contrast to the absence of resemblance, indeed to the dissimilarity, of the Muschelkalk. Throughout those more easterly parts of the Himalaya, the physical characters of the Muschelkalk are practically invariable, and the steep cliff of the nodular limestone always forms a characteristic feature which cannot be mistaken. This, however, appears to be quite absent from Kashmir. So far as the fauna is concerned, Dr. Diener confirms Mr. Middlemiss' view as to the absence of Lower Muschelkalk forms from all the collections hitherto made, whilst every fossil that can be assigned to the Muschelkalk appears to belong to the Trinodosus zone of other parts of the Himalaya. The only upper Triassic fossils in Mr. Middlemiss' collections consist of lamellibranchs and brachiopods, which, although marked by certain Upper Muschelkalk affinities, are regarded by Dr. Diener as, on the whole, indicative of a carnic age.

Fossil plants from Afghanistan.

31. Professor Seward has completed a detailed critical study of the plants collected by Mr. Griesbach and by me in Afghanistan. Mr. Griesbach's collections, which come chiefly from Chahil and Shisha Walang to the north of the Kara Koh (Afghan-Turkistan), are regarded by Professor Seward as perhaps as old as lias or rhætic, whereas my collections, chiefly from the country to the south of the Kara Koh (Saighan and Kahmard), he regards as Middle Jurassic (Inferior Oolite). This rather tends to confirm the suggestion (*Memoirs, Geological Survey of India*, XXXIX, page 77) that the volcanic Doab series of Saighan is represented in Afghan-Turkistan by the estuarine and shallow-water marine deposits which contain *Halobiæ* of Upper Triassic affinities. Professor Seward also confirms the view that the affinities of the Afghan Jurassic flora are with that of the provinces of Fergana and Syr Darya, that is to say, of Angaraland rather than of Gondwanaland.

32. By the kindness of Mr. G. E. Harris, Agent and General Manager of the Assam Railways and Trading Company, I have recently been enabled to send to Professor Seward certain specimens of the Tertiary flora associated with the coal-seams of Margherita in Upper Assam. Good specimens are rare, as the shale rapidly disintegrates on exposure to the atmosphere. In the present instance, however, Mr. Harris had obtained a large fossiliferous block, which he immediately varnished, thus preserving it for some time from the effects of the atmosphere. The fossils consist chiefly of dicotyledonous leaves. which Professor Seward has described under the name *Phyllites kamarupensis.* They are unfortunately not sufficiently distinctive to warrant any statement as to geological age. Professor Seward's paper appears in this part of these *Records*.

Fossil plants from the Assam coal measures.

ECONOMIC ENQUIRIES.

Asbestos.

33. During the course of his survey of Idar State Mr. Middlemiss discovered in the hills to the south-east of Dev Mori (23° 39′ : 73° 28′) a deposit of asbestos, which appears to be of excellent quality. It occurs in large rod-like masses, which, when soaked in water and dried, come out as long silky masses of beautifully white fibre. The mineral is the amphibole variety and is long in staple, some fibres being as much as eight inches in length. The deposit is being opened up by the local authorities and, if it proves to be of any size, should be well worth exploiting.

Idar State.

Coal.

34. During his investigation of the oil-fields of Assam, Mr. Pascoe took the opportunity of visiting the valley of the Namchik river to the north-east of Margherita. Here he discovered a fine seam of coal, some sixty feet thick. The results of his investigation have already been published in the previous volume of these *Records* (Vol. XLI, page 214).

Assam.

35. The proposed borings for coal on the Dilwal plateau of the Salt Range were put down during the latter part of the year, at Tothral and Arar. These villages lie well back from the southern scarp of the range and are separated from one another by a distance of about 2½ miles,

Punjab.

If, therefore, there was a coal-field of any considerable extent below the nummulitic limestone of the plateau, evidence of its presence should be found below Tothral and Arar. No coal, however, was found at Arar, and a seam only a few inches thick at Tothral; at the latter place, the boring was carried to a depth of over 112 feet below the coal into the Olive series, and the general sequence proved to be similar to that at Dandot. The Arar and Tothral sections are given below, and that obtained from the previous boring at Dandot is added for comparison :—

	Arar.	Tothral.	Dandot.
Surface soil, débris and nummulitic limestone .	99′ 3″	117′ 0″	127′ 0″
Variegated shales . .	10′ 6″	10′ 6″	11′ 6″
Limestone with some calcareous sandstone .	131′ 9″	156′ 0″	140′ 6″
Alum shale . . .	27′ 6″	24′ 2″	30′ 0″
Coal-seam . . .	....	1′ 4″	1′ 10″
	Pink marl.	Grey shale.	Dark grey shale.

The persistence in character and thickness of the variegated shales lying between the two bands of nummulitic limestone is very marked, as also is the uniformity of the lower limestone. The results of these borings lead to the inference that the coal-seam is thinner under the Dilwal plateau than in the neighbourhood of Dandot, that is to say, that it thins out and disappears towards the north. The data are of course insufficient to admit of any definite statement to that effect, but they give us no encouragement to expect that the seam under the Dilwal plateau will ever be appreciably thicker than that along the scarp, whilst the results of these investigations hold out no inducement towards further borings on the other plateaux of the Salt Range.

Copper.

36. With a view to the preparation of a memoir on the copper deposits of India, Dr. L. L. Fermor was deputed to Sikkim to

examine the ore-bodies of that State. The most important are those of Bhotang and Dikchu. Both deposits occur interbedded with the associated rocks, being of the nature of interbedded replacement deposits; but whereas the Bhotang deposit is in a comparatively unmetamorphosed form of the Daling series, the Dikchu deposit occurs in the belt of highly crystalline mica-schists with associated gneisses, forming a boundary zone between the Daling series and the Sikkim gneiss. In both cases, the copper-ore is chalcopyrite, the chief associated sulphide being pyrrhotite. But, especially at Bhotang, galena and blende are also of somewhat common occurience. Dr. Fermor finds the origin and mode of occurrence of these ores to be similar to those of the Singhbhum copper-lodes. In each area the lodes are interbedded in the Archaan rocks (Dharwars in Singhbhum and Dalings in Sikkim, the garnetiferous rock of Dikchu being probably a highly metamorphosed form of the Dalings); in each area the bodies of copper-ore have been formed by the metasomatic replacement of the associated rocks; and in each area the copper-bearing formations are close to large masses of granitic rocks, from which, one may conjecture, the copper-bearing solutions were derived. In Singhbhum there are numerous basic (epidioritic) dykes associated with both the granites and the Dharwar rocks (schists, quartzites, etc.), and, as an alternative to the derivation of the copper-bearing solutions from the granites, it is possible to suppose them to be closely connected with the basic dykes. The disposition of the Singhbhum copper deposits as an aureole in the Dharwars following the curvature of the Dharwar-granite boundary is, however, in favour of the former suggestion, which, as it happens, is also more suitable for explaining the derivation of the ores of Sikkim, where basic igneous intrusions are scarce.

37. Although the deposits of Sikkim are similar in mode of origin to those of Singhbhum, they differ from them remarkably in the diversity of their mineral contents, which frequently include chalcopyrite, pyrite, pyrrhotite, blende, and galena; in Singhbhum, on the other hand, the copper-lodes show, as a rule, only two sulphide minerals, chalcopyrite and pyrite—with traces of chalcocite at higher levels, probably representing a zone of secondary enrichment. In both Sikkim and Singhbhum, azurite, malachite, chrysocolla, and chalcanthite, are found in the oxidised zones of the lodes, but in Sikkim where the slopes are very steep

and denudation under the influence of a moist climate and heavy rainfall is very rapid, the oxidised zones are much less prominent than in Singhbhum. In Sikkim the sulphide minerals may crop out at the surface in the fresh condition, but this practically never happens in Singhbhum, where one might doubt the existence of copper deposits, were it not for the presence of numerous ancient outcrop workings stained with green and blue oxidised copper minerals.

38. In August Dr. Fermor also paid a brief visit to the Matigara mine in Singhbhum, where the Cape Copper Company have been prospecting for some little time.

Engineering Questions.

Darjiling landslips.

39. During the early part of October, I visited Darjiling to join a committee convened to discuss the safety of the hill-sides surrounding the station. Attention was chiefly centred on the Happy Valley slip, which was examined in detail; various suggestions were made with a view to preventing further landslips, but final measures were postponed pending a detailed geological survey on a large scale of the whole hill-side from the Court-house to the Jail. It is proposed to undertake this in the summer of 1912. Incidentally it should throw much-needed light on the nature and origin of the Darjiling gneiss, which in the Happy Valley appeared to me to be derived largely from the metamorphism of a pre-existing sedimentary series of slate and quartzite.

Galena.

Simla Hill States.

40. At the request of His Honour the Lieutenant-Governor of the Punjab I visited Basantpur in Bhajji State, the site of the head-works of the Simla hydro-electric installation, where galena and stibnite were said to occur. Specimens said to represent deposits of each had been sent previously to the Geological Survey Laboratory, but had proved to be only galena, no ore of antimony occurring among them. The latter was said to have been found on the left bank of the Nauti Khad just above the flume, and two mule-loads of ore were said to have been taken away. In spite of careful search by

myself as well as by a guide who claimed to have collected ore from the deposit, not a trace of ore of any kind could be found at this locality; it would appear that the whole deposit had been removed.

A few lumps of galena and a considerable amount of slag are found in the alluvium of the stream running from Basantpur to join the Nauti Khad. The quantity noticed was, however, small and is probably derived from the small veinlets and clusters of galena to be seen here and there in the metamorphic limestone which occurs in large quantity in the neighbourhood. Similar occurrences of galena are common throughout the Simla Hill States and are not as a rule of any economic importance.

Gold.

41. On his return from leave, Mr. Coggin Brown was deputed to examine, on behalf of the Sawbwa, the gravels of the Möng Lông Sub-State in Hsipaw, where gold was said to occur in payable amounts. Mr. Brown found that the gravels, although rich in places, occurred in too small quantity to hold out any hopes of successful dredging operations, and recommended that the deposits be left to the Shans to work. A detailed report on the subject has been published in the first part of this volume.

Möng Lông State.

Petroleum.

42. In consequence of the introduction of the Oil-fields Regulation, towards the end of 1910, Yenangyaung was constituted an "oil-field" under the Act and a warden was appointed to take charge of it. At the same time, Mr. K. A. K. Hallowes was deputed to assist the latter officer with advice on technical matters. The Government of Burma subsequently decided to carry out the recommendation of the Oil-fields Committee and to constitute an Advisory Board to assist the warden, and it was considered desirable that a member of the Geological Survey should be on the Board. The Board was constituted in June of the year under review and Mr. Coggin Brown was appointed to represent the Geological Survey; he was subsequently relieved by Mr. Cotter in September. The experiment of constituting the Advisory Board has been entirely successful, and it is probable that the system will become permanent. It will therefore be necessary to arrange for the services of a member of the Geological Survey to be always available, and as it is not

desirable that an officer should be debarred for a long period from the advantages to be derived from spending the recess at head-quarters, it has been arranged to have two members of the Department conversant with the work so that one may relieve the other at Yenangyaung every half-year. For the present Messrs. Cotter and Brown are undertaking the duties.

43. The oil-fields party consisted, in addition to Mr. Cotter, of Mr. K. A. K. Hallowes and Sub-Assistant Sethu Rama Rau. During the early part of the year, Mr. Hallowes was posted to Yenangyaung, but, after the monsoon, resumed field-work in the Pakokku district, where he has been engaged on a survey of the volcanic area in the northern part of the district.

44. In the early part of the year, Sub-Assistant Sethu Rama Rau was engaged in mapping the area included in sheets 113 and 157 (Burma Survey, 1″=1 mile) covering parts of the districts of Minbu, Thayetmyo and Magwe. Three anticlines were noted in this area, *viz.*, (1) the Migyaunge-Kyundaw anticline, (2) the Tagaing-Sinmadaung and (3) the Mindegyi-Kyawdo. Of these the first is approximately symmetrical, and has shallow dips ranging from 10° to 25°, the Pegu beds being continuous with those of the Minbu oil-field. The conditions are regarded as favourable for the storage of oil. The Tagaing-Sinmadaung anticline is asymmetric on the north and symmetrical on the south, but the dips are very high, and the economic possibilities of the area are regarded as poor. The Mindegyi-Kyawdo anticline is a symmetrical one with shallow dips ranging from 10° to 25°. The Pegu beds here are the continuation of those exposed near Yenaman and Thabyemyaung, where seepages are numerous; the area is therefore regarded as decidedly promising.

During the latter part of the year, Sub-Assistant Sethu Rama Rau was engaged in surveying the Pakokku district.

Steatite.

Idar State.

45. Reference has already been made to the asbestos found by Mr. Middlemiss in Idar State. It occurs among, and is closely associated with, large quantities of steatite. The latter is found between Dev Mori and Kundol (23° 40′ : 73° 28′) and also at Ghánta (23° 36′ : 73° 26′). The steatite is of very fair quality and occurs in enormous quantity, Mr. Middlemiss having calculated that at the first locality alone

there are over two million tons in sight and within easy reach. A note on the subject has been published in the preceding part of this volume of the *Records.*

Tin.

Nurunga, Hazaribagh district.

46. In July, Dr. Fermor visited the Nurunga tin locality, already noticed in *Records*, Vol. XXXIII, page 235, 1906; a syndicate, advised by Mr. P. N. Bose, had recently carried out a little exploratory work on the outcrop and had smelted in a local native iron-furnace a small quantity of the ore obtained. No attempt had been made, however, to unwater the old workings and no effective examination of the deposit could therefore be made. The deposit is of a very unusual character, consisting of a thin band, some 6 inches thick at most, of cassiterite-granulite. forming an interbedded layer in a considerable thickness of microcline-granulite: in addition to the band mentioned above—which often contains a very high proportion of cassiterite, as much as 30 to 50 per cent—cassiterite is also found in sparsely scattered granules in the microcline-granulites, especially close to the cassiterite-granulites. Samples of the country-rock have not yet been analysed, but it seems unlikely that the amount of included cassiterite is sufficient to render the whole mass of rock worth treating as an enormous deposit of low-grade tin-ore. The specimens collected have not yet been thoroughly studied. but the mode of occurrence of the tin suggests that the cassiterite-granulite is a basic segregation from the acid granulites with which it is associated.

See also under *Wolfram.*

Water.

47. At the request of the Local Government, it was arranged that a traverse should be made across the Irrawadi valley from the western foot of the hills of the Southern Shan States to the outer ranges of the Arakan Yoma, with a view to ascertaining the possibility of obtaining supplies of water under artesian conditions. The work was undertaken by Mr. P. N. Datta, who made a complete traverse along the latitude of Pyawbwe. On the whole, the result was not very encouraging, but Mr. Datta indicated various spots at which artesian water might be found.

Wolfram.

Burma.

48. At the request of the Local Government, Mr. Page was again posted to Tavoy and Mergui with a view to assisting the local officials with advice in matters relating to tin and wolfram-mining. Owing to the great rush for wolfram concessions in Tavoy and to the complete absence of reliable maps, he found that there was great difficulty and delay in connection with the issue of prospecting licenses. Matters, however, are being gradually reduced to order and it is hoped that before long all pending applications will have been dealt with.

GEOLOGICAL SURVEYS.

Assam.

Mr. E. H. Pascoe: Naga Hills.

49. Having been deputed to Assam for the field-season 1910-11, Mr. Pascoe was permitted to accompany a column that left Kohima early in January for a visit to Makwari on the Assam-Burma border. The greater part of the traverse, which was some 85 miles in length, lay over a monotonous sequence of Disang shales and slates with little to relieve it save occasional lenticles of quartz. Among the Disang beds, between Dimapur and Kohima, was recognised the Naogaon sandstone of Mallet forming the peaks of Kadiuba and Siwenuchika. In the extreme east of the area, occurrences of serpentine were observed corresponding to the band mapped by Mr. R. D. Oldham in Manipur. A thick massive conglomerate was another interesting feature of this part of the traverse. The serpentine has been derived from gabbro and peridotite, pieces of which rocks are common in the streams.

Mr. J. C. Brown: Abor Hills.

50. The despatch of an expedition to the Abor country offered an opportunity for exploration of a tract of which the geological conditions were entirely unknown and it was therefore decided that a member of the Geological Survey should be attached to the force. Mr. Coggin Brown was selected for the purpose and joined at Kobo early in December. Mr. Brown has been able to add largely to our knowledge of this part of the Himalaya and he deserves great credit for the energy and perseverance with which he pursued his work in the face of the many difficulties inseparable from an expedition of the kind. It was anticipated that the general

sequence of strata recognised at different times in the outer zone of the Eastern Himalaya would be more or less followed in the Abor hills, and this proved to be the case. From Kobo northwards the flat alluvium was found to stretch to the foot of the hills as far as Pasighat. In every direction it is covered with dense forest and the luxuriance of the vegetation entirely masks the ground. North of Pasighat the road soon commences to rise over pleistocene deposits lying on a core of Siwalik rocks, and at Janakmukh there is a raised terrace section of pleistocene gravels 150 feet in thickness, the top of which is 350 feet above the present level of the Dihong.

51. The Siwaliks were crossed on the line of march between Pasighat and Rammidumbang, forming the outer lower-lying foothills which flank the higher ground to the north; they were found to consist of great thicknesses of various kinds of sandstones, the softer micaceous varieties often containing nests of bright lignite, undoubtedly the remains of waterloggged drift-wood deposited during the formation of the rocks. Landslips are very common in this zone and from the high Abor "jhums" (clearings) the light coloured Tertiary strata show up well against the dark green of the Sub-Himalayan rainy forest which covers the hills.

52. The Siwaliks dip into the hills and have the customary appearance of being overlain by the Himalayan Gondwanas, the next series met with. Unfortunately no actual contact of the two systems was seen, but there is no doubt that it is the same here as elsewhere. The commonest rock types in this series are white and greyish-white, indurated sandstones and quartzites, reddish ferruginous shales, black carbonaceous shales, often with clay-ironstone septarian nodules, hardened, greyish-blue shales in which a schistose structure has been developed, and coal-seams. Owing to the intense crushing to which they have been subjected the seams have been squeezed into lenticular patches and the coal itself rendered powdery and friable. It is believed that these coals are of no economic value. Near Renging bands of decomposed volcanic rock begin to make their appearance, interbedded with the Gondwanas, and further north there is a great development of trap-like rocks which have given rise to the peculiar physical character of the narrow gorge-like course of the Dihong through the lower Abor hills. These rocks have been named the Abor Volcanic series, but at present, mainly owing to the want of continuous exposures, it is not possible

to fix their exact age, though in the presence of palagonite tuffs they bear a striking resemblance to the Rajmahal traps. This series is followed higher up the valley by metamorphic rocks which in general appearance and position appear to correspond partly with the Daling series of Sikkim.

Bombay, Central India, and Rajputana.

Messrs. C. S. Middlemiss, H. C. Jones, A. M. Heron and N D. Daru.

53. Messrs. Middlemiss, Jones, Heron, and Daru, were engaged in the survey of parts of Bombay, Central India and Rajputana, together with a few connected areas in the Punjab and United Provinces which border the part of Rajputana worked by Mr. Heron.

Mr. Middlemiss: Idar State.

54. Mr. Middlemiss began work in Idar State, and spent from January to April there investigating a portion of the country new to the Geological Survey, but lying immediately south of Hacket's and La Touche's surveyed areas in Rajputana and north of Kishen Singh's mapped areas in parts of Bombay. He completed a well-defined area of about 729 square miles, lying centrally within sheets 118 to 120 and 144 to 146 of the Bombay 1″ = 1 mile survey. The banded and bedded formations represented are a folded (N.N.E.—S.S.W.) complex of Aravalli calc-gneisses and other schists, Delhi quartzites – coming apparently above and folded with the latter,—Ahmednagar sandstone series and recent deposits. The most common form of the first of these, occurring in limited exposures among vast spreads of alluvium, is a thoroughly crystalline aggregate of much calcite with varying amounts of quartz, microcline, plagioclase, diopside and sphene, and occasionally with much biotite, or with wollastonite, scapolite, garnet and zoisite. Among it ramify innumerable small granitic veins of aplite, graphic granite, and pegmatite, which seem to be as old as the folding of the rocks among which they appear. There are also later-intruded, large, rugged and grotesque masses of Idar granite (biotite and hornblende granite) and of quartz-porphyry bursting irregularly through the region regardless of the older series. Long sinuous dykes of vein-quartz (ultra-acid differentiation products of the Idar granite?) and one or two examples of a basic dyke (olivine-gabbro or dolerite), together with a contact, composite or hybrid rock, between the latter and the Idar granite, were also identified and mapped.

Of these intrusive rocks, Mr. Middlemiss specifically identifies the Idar granite with the Siwana and Jalor granites, and the quartz-porphyry with the Malani rhyolites of Western Rajputana (see La Touche, *Mem. Geol. Survey of India*, Vol. XXXV, pt. 1, pages 25 and 90—91) and the olivine-gabbro and dolerite with a very similar one also in Western Rajputana, described by Sir T. Holland (*loc. cit.*, page 91). But there are further resemblances between the two areas in the nearly horizontal Ahmednagar Sandstone series, which appears as cappings on the hills or in the deeply-cut rivers under the alluvium, and which probably represents the Barmer sandstone of Western Rajputana as well as the Lathi group of Jaisalmir and the Umia of Kathiawar.

Economic.

55. No minerals of sufficient importance to notice here have as yet been found, but the sandstone quarries at Ahmednagar yield an excellent free-stone, whilst marble and granite can also be obtained in any quantity.

Mr. Jones : Gwalior.

56. Mr. Jones spent a full season. from November to the middle of May, in the Amjhera and Ujjain districts, continuing the revision of the geological maps of the area and the investigation of the mineral resources of the State. The area is contained on sheets nos. 212 to 215 and 242 to 247 of the Central India and Rajputana Survey (1″ =1 mile). Of this the Bag area to the south took him to the interesting localities already surveyed generally by Messrs. Blanford and Wynne (*Mem., Geol. Survey of India*, Vol. VI, pt. 3) and later again in more detail by Mr. Bose (*Mem., Geol. Survey of India*, Vol. XXI, pt. 1).

57. Although Mr. Jones was primarily concerned with the possibility of finding ores of manganese in the crystalline rocks, he has incidentally contributed a newly coloured map of most of the Bag area in even greater detail as regards delineation of boundaries than the already detailed work of his immediate predecessor Mr. Bose. A feature of special interest in his report of this area, where the sequence of beds comprising Nimar sandstone, Nodular limestone, Coralline limestone, Lameta, and Deccan Trap, lie almost horizontally above the steeply dipping Bijawars or still older gneissic and metamorphic series, is the beautiful set of photographs which he has taken in illustration of this and other physical features. His report may generally be considered as a further study in a number of detailed and well-illustrated sections taken at points

of special interest of the area already liberally treated by Mr. Bose. A further addition to the fossils, of about cenomanian age, collected especially from the Nodular limestone and the Deola and Chirakhan marl has also been made by Mr. Jones. Among these Mr. Tipper has specifically recognised *Hemiaster similis*, *Placenticeras Mintoi* Vredenburg, and *Namadoceras Scindiæ* Vredenburg. As before, no fossils were obtained from what have been called Lameta beds at the base of the Deccan trap, so that the points in debate with regard to that formation remain as they were.

Economic.

58. No manganese nor anything of special economic importance was found. In the Bijawar rocks near Bag, however, Mr. Jones found promising slates, and he has suggested that pits be opened in them to determine their quality and suitability for roofing, writing slates, etc.

Mr. Heron: Rajputana, Punjab and United Provinces.

59. From the middle of November to the first week in May Mr. Heron spent a full season in continuation northwards, eastwards and south-eastwards of his work in Alwar of the last two seasons. The formations exposed constitute isolated hill groups, gradually dying out in the Indo-Gangetic alluvium to the west of the Jumna, during which process they spread out from Rajputana (whence the work of determination originated) into the neighbouring areas of Delhi and Gurgaon districts of the Punjab, and Agra and Muttra districts of the United Provinces of Agra and Oudh. This large area is included in Atlas of India sheets 49 and 50 (1″=4 miles), and standard sheets (1″=1 mile), Punjab Survey nos. 321 to 325, Central India and Rajputana Survey nos. 283, 284, 312, 313, 337 to 341, 360 to 362, and United Provinces Survey no. 23, all of which are now completely surveyed.

60. The rock systems include those of the Alwar State already described in previous reports by Mr. Heron, namely, Aravallis (schist series of Hacket), above these the Alwar quartzite series, which in the Biana hills becomes split up into several groups, and above these the Ajabgarh (Mandan) series of slates, shales, etc. Besides these, in the area surveyed there are examples of Hacket's "Gwaliors" of Hindaun (thinly laminated cherts with jasper layers) and the Bhander and Rewa sandstone stages of the Upper Vindhyans, which are not found in Alwar.

61. Notwithstanding the large surface covered, practically only one sheet (Central India and Rajputana no. 341) presents any

variety of geological feature. This is embodied in the hilly mass of Alwar quartzites north-west of Biana and the Upper Bhander scarp to the south. The rest of the sheets comprehend long tailing-out ridges or hill-masses of either the Alwar series and Ajabgarhs with a few pegmatite veins, or of the Rewa and Bhander stages in monotonous regularity, the greater part of the structure of the country and all geological boundaries being hopelessly buried under the all-pervading alluvium.

62. With reference to the Biana hills in sheet 341, it is to be noticed that Mr. Heron upholds Hacket's sub-divisions of the Alwar series into five groups (*Rec., Geol. Surv. India*, X, 87 and XIV, 298), with one unconformity and several conglomerates indicating breaks in the succession. Near the middle of the lowest group (the Nitahars) there are two bands of volcanic rocks, traps and tuffs, the former of which Mr. Heron has determined as a dolerite in which the plagioclase has been replaced by quartz and muscovite or kaolin, and the augite by chlorite.

The "Gwalior" cherts of Hacket, Mr. Heron thinks, may belong to the schist series and not to the true Gwaliors.

Economic.

63. Impure graphite and a tradition of gold at Sohna, some old copper workings west of Nitahar and the kaolin of Kasampur have long been known and are mentioned in the *Manual of the Geology of India*, Vol. III. Nothing further of importance has been found by Mr. Heron in connection with them. He describes, however, an excellent band of slate at present being worked by the Kangra Valley Slate Company near Kund railway station. Building stone from the long-celebrated Upper Bhander sandstone quarries in Bharatpur State is of excellent quality.

Mr. Daru: Banswara and Dungarpur.

64. Mr. Daru spent only a very short field-season engaged in the above survey, namely, the months of March and April. During the first fortnight of this he was occupied in Banswara, the completion of the survey of which left him free to pass northwards and westwards into new ground in Dungarpur, where he surveyed 250 square miles in the extreme north-east of that State (sheets 175 and 176 of the Central India and Rajputana Survey). Mr. Daru describes the area as being entirely of Aravalli rocks, with igneous intrusives and a few patches of recent alluvium, most of the country

being a continuation north-west along the strike of the formations as found in Banswara.

65. The Aravallis are of the "argillaceous" type, generally biotite schist, occasionally with garnet and staurolite, sometimes too with a large proportion of magnetite. This passes locally into quartz-schist. There is also found hard shale, phyllite, graphitic shale, muscovite schist, hornblende schist and apatite schist. Boulder beds preponderate in one area east of the Sabla chain of hills. Limestone is comparatively rare, such outcrops as occur being extensions from the Banswara area. Two bands of ferruginous cherty quartzite are found, also in extension of the Loaira rock from Banswara.

66. The intrusives in these consist of aplite, graphic granite and muscovite pegmatite, occasionally with tourmaline; and there are also quartz-felspar rock and vein-quartz, the latter being in both large and small veins and regarded as extremely acid representatives of the pegmatites. Granite, gneissose granite, syenite and diorite are also found. In two or three bands there are also examples of "interbanded quartz-hornblende schistose intrusives."

Economic.

67. No minerals of economic importance occur in sufficient quantity or quality to be worth exploitation. The apatite schist may perhaps be put to some use, but its quantity is unknown as it is largely obscured by soil.

Burma.

Mr. P. N. Datta.

68. The work of the Burma party has already been referred to under *Petroleum* and *Water*. In addition to the systematic survey being carried out in the oil belt, a survey was begun by Mr. Datta of the country lying along the western foot of the Shan Hills from Kyaukse southwards. Work was only begun just before the end of the year and there is therefore but little to report. Mr. Datta finds that the country in the neighbourhood of Kyaukse consists of an altered sedimentary series, now consisting of argillite, quartzite, micaceous schist and marble, associated with biotite granite to which the metamorphism of the sedimentary rocks is probably to be attributed.

Central Provinces.

69. It was decided this year to form a new field party, in addition to those already at work in Burma and Central India, the

new party being for the systematic survey of the Central Provinces on the scale of 1″=1 mile. Previous work in this province has been carried out on a variety of scales, and much of the province is practically unsurveyed. The party has been placed under the charge of Dr. Fermor, and, as constituted for the field-season of 1911-12, includes also Messrs. H. Walker and C. S. Fox, Assistant Superintendents, and M. R. Ry. Vinayak Rao, Sub-Assistant. Babu Bankim Bihari Gupta, recently promoted from the post of Museum Assistant to one of the newly sanctioned posts of Field Collector, was also sent with this party in order to collect a typical series of Chhindwara rocks. The first area selected for survey comprises, on the northern line, the districts of Betul and Chhindwara as far north as the Satpura coalfields, and the districts of Seoni and Mandla as far north as the district boundaries, and, on the southern line, the districts of Nagpur, Bhandara and Balaghat as far south as the Bengal-Nagpur Railway line. This area has the advantage of being, as far as is known, a homogeneous geological entity, including a large proportion of unmapped country and the whole of the Central Provinces manganese-ore deposits with the exception of those of Jubbulpore. Maps on the 1″ scale are available for the whole of this area with the exception of the Nagpur district, of which the largest maps available are on the scale of 1″=2 miles. The Surveyor-General has, however, kindly modified the programme of work of the Survey of India party now engaged in preparing new maps of the Central Provinces and Berar so as to issue the topographical sheets of this district within the next two or three years. Meanwhile, work was commenced during the current field-season (1912-13) on the northern line of districts. The Betul district has been assigned to Mr. Walker, whilst the remainder of the party accompanied Dr. Fermor to the Chhindwara district in order to become familiar with the rock formations, the study of which was commenced as long ago as 1903 (Fermor, *Records*, XXXIII, pages 159—218, 1906). Sub-Assistant Vinayak Rao has since been sent to Seoni to commence mapping in that district on the lines established at Chhindwara, whilst Messrs. Fermor and Fox propose to survey the Chhindwara district jointly, as it contains a large area of varied Archæan rocks and gives a section across the Satpura Hills from the 1,000-ft. Nagpur-Balaghat plain on the south,

Messrs. L. L. Fermor, H. Walker, C. S. Fox and M. R. Ry. Vinayak Rao.

across the Chhindwara plateau (2,200-ft.) in the middle, to the Mahadeo Hills bounding the southern edge of the Narbada valley on the north and frequently rising to elevations of over 3,000 feet. It is expected that a detailed survey of this district will furnish the key to the structure both of the Satpura Hills, which traverse the northern line of districts, and of the Archæan plains comprising the larger portion of the southern districts.

Deccan Trap.

70. In the short portion of the current field-season falling within the year under review, the only work carried sufficiently far for report here is the detailed mapping of some 70 square miles of Deccan Trap lying on the 2,200-ft. plateau round the villages of Linga and Lahgarua, to the south of Chhindwara town. Dr. Fermor began detailed work on this area with the object of determining, in the first place, whether it would be possible to break up the Deccan Trap formation into divisions sufficiently well-marked to be easily mapped, or whether it would be necessary, as seemed probable, to colour the whole of this formation with one tint. Incidentally he wished to study in some detail the inner relationship of the vast succession of lava-flows, especially as to origin. Mr. Harker has expressed the view, in his *Tertiary Igneous Rocks of Skye*, that the columnar doleritic flows interbedded in the Tertiary basic lavas of that island are sills intruded between the flows of extrusive basalts. To ascertain whether or not such an explanation could be applied to the Deccan Trap, it was decided to map, flow by flow, a selected area in which the existence of dolerite had been ascertained. Dr. Fermor and Mr. Fox first mapped a portion of the area jointly, determining the existence of four distinct flows; they then separated, Mr. Fox carrying the boundaries to the northern and western edges of the selected area and Dr. Fermor to the southern and eastern. The results of their work are of considerable interest. Each flow—except the uppermost, the surface of which has been denuded away—shows a vesicular, more or less amygdular, surface; and between each pair of flows there is usually an 'intertrappean' layer. This sometimes takes the form of a silicified sedimentary stratum a few feet thick—in some cases of limestone, and still frequently containing abundant silicified fossils, *Physa*, *Paludina* and *Lymnæa* (?) —whilst in others the intertrappean layer consists of a green clay, the 'green earth' of Indian geologists, sometimes associated with brownish and cream-coloured clays. The origin of this green earth

seems to vary; in some cases, it has undoubtedly been formed by the alteration of the underlying lava surface, but in other cases the origin is doubtful. Sometimes both green earths and sedimentary intertrappeans occur together, the green earth usually overlying the sedimentary rocks. Mr. Fox has collected for careful study a series of specimens of green earths and green jaspers, both from these intertrappean layers and from the lava flows themselves.

71. The flows are numbered serially 1 to 4 from below upwards, flow 1 being the true basal flow in this area, as it rests directly upon the Chhindwara granite. With the exception of flow 2, all have normally the texture of basalts, but any flow may be exceptionally more coarse-grained, *i.e.*, doleritic. Flow 2 is, however, usually a crystalline dolerite, and if any flow were to prove intrusive, it should be this one. Several other doleritic flows were discovered later in the season on the edge of the ghats fringing the Kanhan valley, but nowhere was any evidence of intrusive relations detected. On page 259 of the *Manual of the Geology of India,* second edition, the existence of phenocrysts of olivine in the Deccan Trap is referred to; but it is probable that the phenocrysts of plagioclase, so abundant in the basalts, have been mistaken macroscopically for olivine, for none of the officers working on the Deccan Trap formation of recent years have been able to detect this mineral in thin sections under the microscope, although serpentinous patches are commonly seen, representing in some cases, perhaps, original olivine. It is interesting to record, therefore, that both Dr. Fermor and Mr. Fox independently discovered olivine in flow 2, in which it appears to be a normal constituent, although frequently altered completely to serpentine, and rarely quite fresh. The separate flows do not rest on each other with horizontal surfaces, and by the judicious use of the aneroid, frequent surprisingly high variations of a particular flow from one point to another have been detected. Marked dips of several degrees have been noticed in many places. As it was uncertain whether any or all of these dips were to be regarded as due to tectonic disturbances or were to be attributed to the flows adjusting themselves to the irregularities in the surface of the underlying Archæan peneplain, Mr. Fox returned to the area at the end of the field-season when nearly all the streams were dry and the crops cut, so that the exposures could be easily traced; as the result of this he has obtained

evidence supporting the former supposition, and has succeeded in tracing out the position of gentle synclines and anticlines striking north by west and south by east. The probable truth of the explanation of these dips as due to post-Deccan Trap tectonic disturbances is supported by several marked dips observed by Dr. Fermor on descending the edge of the Deccan Trap plateau by the Ramakona ghat. Dr. Fermor emphasizes that this system of folding may be tectonically of considerable importance and that the credit for its discovery is due entirely to Mr. Fox. It is not unlikely, however, that when the observations obtained are carefully worked out, some of the irregularities will prove to be due to the adjustment of the flows to the underlying Archæan peneplain.

72. The result of this work has been to show the possibility of mapping the Deccan Trap in detail, although it has proved exceedingly difficult and slow work; but, unfortunately, it will not be possible to continue this detailed work owing to limitations of time, although it is evident from the discovery of the gentle folds in the Deccan Trap referred to above that further detailed work might yield valuable results from the tectonic point of view. Further, this work indicates that there is no practicable grouping of the flows in this area suitable for mapping.

The Shikarpur craterlets.

73. Whilst carrying out the detailed survey of the Deccan Trap lavas referred to above, Dr. Fermor discovered a series of remarkable, more or less circular, depressions in the surface of flow 1 in the Kulbehra river opposite to the village of Shikarpur. There are in all some 20 of these depressions varying from 3 to 23 feet in internal diameter. Some of them are beautifully circular, and, where filled with water, look as if they had been drawn with a pair of compasses, whilst others are oval or somewhat irregular in shape. Almost invariably these depressions have a raised rim (1 to 3 feet high) separating them from the surrounding lava surface. Whilst the material composing these rims is a compact, comparatively non-vesicular lava, that composing the main surface of the flow is vesicular and amygdular, as also is the lava occupying the interior of these depressions, where seen. The exact nature of these depressions is difficult to understand, but Dr. Fermor is inclined to regard them as vents formed on the surface of flow 1 as outlets from that

flow only, probably for steam and gases, and perhaps also in some cases to release lava from still molten pools within the body of the partially solidified flow. There is some evidence of lava piled up by the side of one of these depressions. It is proposed, therefore, to call them 'craterlets,' in the absence of any better name. Nothing in the least like them is known anywhere in the Deccan Trap formation, except the gigantic Lonar Lake crater in Berar, which must have been formed after the close of the Deccan Trap extravasations; whilst these Shikarpur craterlets must have been formed before the eruption of flow 2 in the Chhindwara district and have been exposed by subsequent denudation.

Punjab.

74. The survey of the Tertiary rocks of the outer Himalaya in Kangra and the Simla Hill States was continued by **Dr. G. E. Pilgrim**, who was accompanied by Sub-Assistant Vinayak Rao. Dr. Pilgrim's general conclusions were referred to in last year's report and need not be recapitulated here. A considerable area was mapped on a scale of 1″=1 mile.

Sikkim.

Dr. L. L. Fermor.

75. During his visit to Sikkim, Dr. Fermor took the opportunity of travelling as far north as Lamteng in the Lachen valley, in order to obtain an idea of the nature of the crystalline rocks lying between that place and Gangtok, and especially to examine the crystalline limestones (*Mem., Geol. Survey of India*, XXXVI, page 18) for purposes of comparison with those of the Chhindwara district, Central Provinces (*Records*, XXXIII, pages 195—206, 1906). Until larger-scale topographical maps of Sikkim are prepared, it will not be desirable to map the geology in greater detail than is shown on Mr. P. N. Bose's map in *Records, Geol. Survey of India*, XXIV, which may be accepted as roughly correct. This map shows a large shield-shaped area of Dalings with the point of the shield to the north; the eastern edge of the shield has a north-north-west trend, corresponding with a similar strike of the Dalings and a general east-north-east dip under the crystalline complex, which extends from this boundary right up the Teesta, Lachen and Lachung valleys. This crystalline complex comprises both igneous and sedimentary rocks, the former consisting chiefly of varieties of biotite-gneiss, and the

latter principally of limestones, calciphyres. mica-quartz-schists and quartzites. A large-scale map would show these para-schists as long strips striking north-north-west parallel to the strike of the ortho-gneisses, and Dr. Fermor advances the tentative view that these strips, which are presumed to be of sedimentary origin, represent portions of the Daling series folded in with the ortho-gneisses and rendered at the same time thoroughly crystalline. The Dalings may well be the equivalents of the Dharwars of the Peninsula (*Mem., Geol. Survey of India*, XXXVI, page 66), and in this case we may regard the associated gneisses as the foliated forms of post-Dharwar granites intrusive with regard to the Dalings. In support of this view of the nature of these para-schists, it is interesting to notice that the slates of the Daling series become more crystalline—phyllitic—as the gneiss boundary is approached.

DICOTYLEDONOUS LEAVES FROM THE COAL MEASURES OF ASSAM. BY A. C. SEWARD, M.A., F.R.S., *Cambridge.* (With Plates 17 and 18.)

THE fossil leaves described in this paper were sent by the Manager of the Assam Coal Company at Margherita to the Director of the Indian Geological Survey, who submitted them to me in the hope that they might furnish evidence as to the age of the Assam Series.

In an account of the Coal-fields of the Naga Hills, Mr. Mallet [1] refers to some imperfectly preserved leaves identified by Dr. Feistmantel as those of dicotyledonous plants and assigned by him to a Tertiary or, at latest, a Cretaceous horizon. A comparison of the Assam Coal-beds with the Nummulitic Series of the Punjab led Mr. Medlicott to suggest a middle Tertiary age, and this conclusion, accepted by Mr. Mallet, has been generally adopted. Mr. Hayden, [2] in a recently published account of the Coal-fields in north-eastern Assam, refers to the general acceptance of Medlicott's estimate of the age of the strata and speaks of the lack of determinable fossils as a serious difficulty in the way of confirming or correcting previous views.

The specimens from Margherita, contained in a block of shale, consist of numerous partially carbonised leaves which clearly represent two distinct types. There are also a few pieces of flattened and longitudinally striated stems or branches, too incomplete to be determined.

The data are insufficient to warrant any definite statement in regard to geological age, though, on the whole, it would seem more likely that the plants belong to a Tertiary than to a Cretaceous flora. It must, however, be admitted that this expression of opinion is not supported by adequate or convincing evidence.

Although the leaves cannot, in my opinion, be assigned to genera other than the provisional genus Phyllites, with any degree of confidence, they are nevertheless worth figuring as new records which it may be possible, with the help of more complete material

[1] Mallet, F. R., *Mem. Geol. Surv. India*, Vol. XII, Pt. 2, p. 269, 1876.
[2] Hayden, H. H., *Rec. Geol. Surv. India*, Vol. XL, Pt. 4, p. 283, 1910.

and specimens of fruits or seeds, to identify with more precision in the future.

Phyllites kamarupensis[1] *sp. nov.* (Pl. 17, figs. 1—3; Pl. 18, fig. 4.)

One of the better specimens, represented in fig. 4, consists of an almost complete leaf, oblong-elliptical in shape, 20 cm. long, with a maximum breadth of 8·5 cm.; the lamina is entire and tapers gradually towards both base and apex. The apparent lobe at the base is due to tearing. There is a strong midrib from which alternate secondary veins are given off at an angle of about 60°: neither the termination of the secondary veins nor the finer venation can be seen in this specimen, which is smooth and polished as though slicken-sided. As seen in other examples (fig. 1) the secondary veins bend rather sharply upwards near the margin of the lamina and are apparently of the camptodrome type, that is, they do not run to the edge of the leaf but bend upwards and shade off into finer veins. Each of the secondary veins extends distally nearly as far as the vein above it in the intramarginal region of the lamina, but I have not been able to recognise a definite connection between the upturned portions of adjacent veins. There are apparently no connecting loops such as form a prominent feature in many large leaves of this type. From the secondary veins tertiary veins arise approximately at right angles, and these give off smaller branches to form a reticulum of polygonal meshes in which the ultimate veinlets end blindly (figs. 1 and 3, Pl. I). In most cases the tertiary veins are very obscure and can be seen only in a few places. The piece of lamina shown in fig. 3 belongs to a leaf 12 cm. broad; the edge of the lamina is not preserved.

The smaller leaf represented in fig. 2 is of the same type; the very slight inequality in the breadth of the lamina on the two sides of the midrib may indicate that it was originally not quite symmetrical and, if so, this may mean that it is a leaflet of a large compound leaf and not a simple leaf. There is, however, no sufficient reason for believing that the specimens are not simple leaves.

The leaves when complete must have reached a length of 25—30 cm. without the petiole, and a breadth of 12 cm.

The widespread occurrence of leaves agreeing generally with *Phyllites kamarupensis*, in different families of dicotyledonous plants,

[1] My friend, Prof. Rapson, informs me that Kāmarūpa is the old Sanskrit name for the region now known as Assam.

is dealt with on a later page: the important point is that the available data do not admit of a reference of the fossil specimens to any one family of dicotyledonous plants.

Phyllites sp. [Cf. *Nerium* spp.] (Pl. II, figs. 5, 5A, 6.)

The fragment reproduced natural size in fig. 5 is part of a broadly linear or lanceolate leaf with an entire lamina, a well-defined midrib, and numerous parallel secondary veins connected by finer anastomosing branches (fig. 5A). In the larger example (fig. 6) the venation is very obscure, but on slight magnification indications of secondary veins can be recognised, showing that it agrees with the smaller piece represented in fig. 5.

The type of leaf illustrated by the specimens spoken of as *Phyllites* sp. is much less common among recent plants than that represented by the large elliptical, oblong leaves. The leaves of the Oleander, *Nerium Oleander*, L., and another species of the genus, *N. odorum*, Sol., which occurs in the outer north-western Himalayas and Central India, present a very close resemblance to the Assam fragments, a similarity which may have a taxonomic significance. It is, however, worthy of remark that the leaves of the genus Calophyllum and *Garcinia echinocarpa*, Th., are also characterised by a similar disposition of the secondary veins. In the absence of more convincing evidence than is afforded by the fossils it would hardly be justifiable to employ the generic designation Nerium.

General Remarks.

The type of leaf illustrated by *Phyllites kamarupensis* is unfortunately one of the commonest among tropical and sub-tropical Dicotyledons, and in the absence of any supplementary evidence in regard to flowers, fruits, seeds, or anatomical characters of the vegetative organs it is, I venture to think, impossible to assign a plant represented solely by imperfect specimens of such leaves to any one genus or even family. At first sight one may be struck by a certain resemblance to recent species of the genus Magnolia, a genus to which several Cretaceous and Tertiary leaves have been referred by palæobotanical writers; but a comparison of the Assam fossils with recent species reveals certain differences which constitute a strong argument against the employment of the designation Magnolia. The large oblong-elliptical leaves of *Magnolia pterocarpa*, Roxb., a species represented in the Assam flora, agree

generally in size and shape with the fossils, but in the recent species the secondary veins are much straighter and are connected by intramarginal loops which arise by forking of the secondary veins near the leaf-margin; in the fossil leaves there are no loops and no indications of such bifurcation of the veins as is seen in Magnolia.

An inspection of published figures of fossil leaves referred to Magnolia, especially after an examination of a large number of leaves chosen from several families, convinced me that in many cases the specimens cannot be accepted as trustworthy records of that genus. The few references given in the footnote[1] may be consulted as illustrating the nature of the evidence on which Cretaceous and Tertiary leaves have been attributed to Magnolia. It is not denied that some of the species recorded by the authors referred to may be correctly included in that genus; but there can be little doubt that a considerable number of the supposed Magnolias should not be accepted as authoritative records without a careful examination of the actual specimens or at least of the published drawings. In the case of most of the species there appears to be no sufficient reason for assigning the leaves to Magnolia in preference to many other recent genera possessing foliage of the same type.

This criticism, though made with special reference to Magnolia, is, I believe, applicable to a large number of Cretaceous and Tertiary dicotyledonous species. It is very important that the task of examining critically the scattered records of the later geological floras should be undertaken. In many cases only negative results would be obtained; but if careful revision of species leads to the rejection

[1] Lesquereux, L. (I) Contributions to the Fossil Flora of the Western Territories, Pt. 1. The Cretaceous Flora, *Rep. U. S. Geol. Surv. Territories*, Vol. VI. Washington, 1874.

(II) *Ibid*, Pt. 2, The Tertiary Flora, *Rep., Vol. VII*, 1878.

(III) Illustrations of Cretaceous and Tertiary Plants of the Western Territories of the United States. *U. S. Geol. and Geogr. Surv. Territories.* Washington, 1878.

(IV) The Flora of the Dakota Group (a posthumous work, edited by F. H. Knowlton), *U. S. Geol. Surv.*, 1891.

Heer, O. A. (I) Flora Fossilis Arctica, Vols. VI and VII (Die Fossile Flora Grönlands), 1882-83.

(II) *Ibid*, Vol. V, (Beit. Mioc. Flor. Sachalin), 1878.

Nathorst, A. G. Contributions à la Flore fossile du Japon. *Kongl. Svensk. Vetenskapsakad. Hand., Bd. XX, No. 2*, 1883.

Dawson, J. W. On new species of Cretaceous Plants from Vancouver Island. *Trans. R. Soc. Canada, Sect. IV*, 1893.

Hollick, A. The Cretaceous Flora of Southern New York and New England. *U. S. Geol. Surv.*, 1906.

of many determinations as untrustworthy, this would at least have the effect of increasing the value of the species which remained after a strict scrutiny. As I wrote some years ago in reference to the neglect of fossil flowering plants, "we have spent our time magnifying the unpromising features of the work instead of testing the capabilities of the available material."[1] The task would unquestionably be laborious and could be accomplished only by those who recognise the limitations both of the material and, one may add, in most cases, of their own unaided efforts in the identification of fragmentary fossils. With the assistance of experts in different branches of systematic botany it would be possible to provide the student of phytogeography with accredited data in place of the long lists of species in palæobotanical literature which bear witness rather to the temerity or ingenuity of authors than to the wanderings of genera since the flowering plants assumed the dominant position in the vegetation of the world.

In order to test the possibility of identifying the Assam leaves with a reasonable degree of confidence, I consulted members of the staff at the Royal Gardens, Kew, and other botanists in the Botanical Department of the British Museum. To these gentlemen I am under considerable obligation for assistance willingly given and for the interest they showed in my quest.

As Colonel Prain and Dr. Stapf pointed out, it is in the first place by no means easy, in the case of impressions such as those of the larger Assam leaves, to decide whether the fossils are simple leaves or leaflets of compound leaves. It would seem that in the Assam specimens the lamina is symmetrical or very nearly so about the midrib, whereas the leaflets of a compound leaf are usually more or less markedly asymmetrical. It is, however, not always easy to detect any departure from longitudinal symmetry in some leaflets, nor is it legitimate to assume that a symmetrical blade necessarily denotes a simple leaf. The leaves described as *Phyllites kamarupensis* are probably simple, but this can hardly be accepted as more than an opinion based on probabilities and not supported by actual proof.

The existing flora of Assam affords examples of plants with compound leaves bearing leaflets comparable in size, shape, and venation with *Phyllites kamarupensis.* Such are *Amoora Rohituka,* W. and A., the leaflets of which attain a length of 9 inches,

[1] The Origin of Flowering Plants. *New Phytologist,* Vol. II, p. 234, 1903.

Chisoceton paniculatus, Hiern, with leaflets 10 inches long, and *Dysoxylum procerum*, Hiern. These are all members of the family Meliaceæ. Some species of Ailanthus (family Simarubaceæ) and Canarium (family Burseraceæ) may also be mentioned in this connection.

One feature of importance from the point of view of comparison between fossil an drecent leaves is the arrangement of the secondary veins, especially their behaviour near the margin of the lamina.

In *Phyllites kamarupensis*, as already stated, the secondary veins bend sharply upwards near the edge of the lamina and, so far as can be seen, they show no bifurcation in the intramarginal region and no connecting loops. Many recent leaves, agreeing in other respects with the Assam fossils, differ in the possession of strong intramarginal loops. This character is subject to variation in a single leaf: loops may be an obvious feature in the middle and upper part of the blade but very feebly developed near the base. *Artocarpus rigida*, Blume, is a case in point. Another feature worthy of consideration is the arrangement of the tertiary veins: in some recent leaves the secondary veins are connected by rather closely disposed veins in a more or less regular parallel series, while in others the parallelism of these finer veins is much less marked and a polygonal reticulum is the more prominent feature.

In *Phyllites kamarupensis* the state of preservation renders it difficult to speak positively as to the nature of the finer venation, but it would seem (Pl. I, fig. 3) that the tertiary veins do not form well-marked parallel series. In this character also there may be a lack of uniformity within a single leaf: towards the distal ends of the secondary veins the connecting tertiary veins may be farther apart and less regular in their arrangement than in other regions of the lamina.

The following recent species,[1] the majority of which are represented in the vegetation of Assam, are chosen in illustration of the very close agreement between the fossil specimens and the leaves of several genera selected from different families. A longer list could easily be compiled; but the plants enumerated may suffice to demonstrate the difficulties to be faced by students who attempt to identify

[1] For a fuller description, see D. Brandis, *Indian Trees*, London, 1906: and J. D. Hooker, (with the assistance of various botanists), *The Flora of British India*, London, 1872—97.

portions of vegetative shoots preserved as fossils, particularly when the leaves are of the exceedingly common type represented by *Phyllites kamarupensis.*

Magnoliaceæ.

Magnolia pterocarpa, Roxb.

M. Pealiana, King.

Reasons have already been given against the attribution of the fossils to this genus.

Anonaceæ.

Anona squamosa, L. (The custard apple; indigenous in the West Indies; cultivated in India.) The leaves of this species are rather smaller than those of *Phyllites kamarupensis,* but those of some other species of Anona show a closer resemblance, especially in the venation.

Ceratobotrys crassifolius, Hook. f. and Th.

Usaria macrophylla, Roxb. The leaves of this species, 5—12 inches in length, agree very closely with the fossils.

Fagaceæ.

Quercus spicata, Sm. In size, shape, and venation, as also in the strong midrib, this species exhibits a striking resemblance to the Assam leaves.

Myristicaceæ.

Myristica Kingii, Hook. f.

M. linifolia, Roxb. Leaves reach a length of 20—30 inches.

Lythraceæ.

Lagerstrœmia macrocarpa, King

L. Flos Reginæ: leaves smaller, but with very similar secondary veins.

Moraceæ.

Artocarpus rigida, Blume.

Rubiaceæ.

Gardenia tubifera, Wall.

Guttiferæ.

Garcinia Griffithii, T. Anders.

Burseraceæ.

Canarium secundum, Bean. The compound leaves have leaflets up to 6 inches long.

Anacardiaceæ.

Buchanania latifolia, Roxb.
Semecarpus Anacardium, Linn. f. In this species the secondary veins are more like those of Magnolia.
Mangifera pentandra, Hook. f.

Ericaceæ.

Rhododendron Falconeri, Hook. f. A very similar type of leaf with a blade 6—15 inches in length.

Dipterocarpaceæ.

Hopea Wightiana, Wall.
Dipterocarpus spp.

Ternstrœmiaceæ.

Camellia Riquetiana, Pierie.

It is far from my desire to exaggerate the difficulties confronting those who undertake the revision of described species of flowering plant founded on leaves or the identification of fresh material. My contention is that a great many of the determinations of fossil Angiosperms have little or no value as botanical records. Assuming the truth of this statement, the question may fairly be asked,—Is it desirable to spend time on the examination of fossil leaves if the identification of a large proportion of them is hopeless? The answer is that good service would be rendered by a critical revision of existing lists of fossil genera and species of Angiosperms, even though little more were achieved beyond the elimination of such records as could not be accepted as trustworthy by competent judges. The work would be tedious and extensive and "beyond the power of the great majority of botanists to undertake single-handed."

An urgent need is "an organised exploration of the later plant-bearing strata and of the wealth of material already collected, which should be taken in hand by experienced palæobotanists in conjunction with botanists who possess a wide and accurate knowledge of recent Angiosperms."[1]

The importance of searching for fruits and seeds has not been fully recognised: in beds containing well-preserved leaf-impressions these are seldom found, but if greater stress were laid on their importance as factors in determining affinity there would be the greater chance of securing the valuable evidence supplied by reproductive shoots. Such work as that of Mr. Clement Reid, ably assisted by Mrs. Reid, affords a striking illustration of the possibilities of investigations on the seeds and fruits of Tertiary and post-Tertiary flowering plants.

EXPLANATION OF PLATES.

With the exception of fig. 5A, all the drawings are natural size.

PLATE 1.—*Phyllites kamarupensis*, sp. nov.

PLATE 2.—FIG. 4.—*Phyllites kamarupensis.*
FIGS. 5, 5A, 6.—*Phyllites*, sp.
(Fig. 5A: a portion of fig. 5 enlarged three times.)

[1] Seward, *New Phytologist*, Vol. II, p. 244, 1903

NOTES ON THE POTING GLACIER, KUMAON HIMALAYA, JUNE 1911. BY CAPTAIN GRINLINTON, R.G.A. (With Plates 19 to 26.)

First observation of position of snout in 1906.

1.—The position of the snout of this glacier was fixed in October 1906 by Messrs. G. de P. Cotter and J. Coggin Brown of the Geological Survey of India.[1]

The main object of the journey to the glacier, the results of which are recorded in these notes, was to see if any evidence of secular change of position of the snout since October 1906 could be collected.

Besides the above, it was hoped that some evidence as to the former extension of the glacier might be discovered, and an endeavour was made to collect some data as to the physical condition of the ice, and its general behaviour.

Visit of June 1911, much snow.

In 1911 the visit was made during the first two weeks in June. The actual time spent on the glacier was, however, very short. The party arrived on the afternoon of June 6th and, through untoward circumstances, had to leave at mid-day on the 9th June.

There was still much snow about at this time. The Poting gár (glacier stream) from the snout right down to Bugdiar was bridged at frequent intervals and for long distances by snow, still 2 to 4 feet deep.

2.—The snout itself was fairly free from snow, though the stream for 800 yards below it was quite bridged. The upper portion of the glacier was still deeply covered on the south-west side.

Immediately on arriving at the camping ground near the glacier a search was made for the marks ⋏ cut in the rock at the stations A, B, C.[2]

Condition in 1911 of the marks cut in 1906.

Those at ⊙A and ⊙B were found at once, and were in excellent condition. That at ⊙B has been painted in with red paint, which was in such good condition that it did not need repainting. The mark

[1] *Records, Geol. Surv. Ind.*, Vol. XXXV, Part 4, 1907.
[2] *Records, Geol. Surv. Ind.*, Vol. XXXV, Part 4, plate 65.

at ⊙A had no red paint in it; it looked quite clear, clean cut and new. The white colour was so conspicuous for sighting that it was not painted.

The mark at ⊙C was covered deep in snowdrift at the time of the visit and was never seen. Its *horizontal* position was fixed by tape and compass for a temporary photo station,[1] and the plotted results show that the position found was very close to that of ⊙C, though as the snow was deep the temporary station ⊙C_I must have been some feet higher than the true ⊙C; probably something of the order of 10 feet.

Position of snout in 1911, practically the same as in 1906.

3.—An examination of the tabulated results[2] of the measurements to ⊙K (Cairn of 1911) shows that the snout is in practically the same position as in 1906. There seems to be some slight evidence of a very small retreat, but this may be seasonal.

The general condition of the glacier, however, speaks of vigour, and if it is retreating it is certainly contesting every inch of ground lost.

Left lateral moraine now very active.

The most striking feature at present is the left lateral moraine. The general elevation of this member above the rest of the glacier and the signs of activity exhibited by it are most interesting. A general description of the glacier member by member and a short sketch of the salient points of the valley seems the best way of conveying an impression of the whole.

These will be taken in the following order :—

(1) Poting valley, (2) The glacier snout, (3) Terminal moraines, (4) Left lateral moraine, (5) Right lateral moraine, (6) Surface moraine, (7) Crevassing, (8) Ice fall or cascade, (9) Névés. The structure and other points as to the ice itself will be dealt with as they occur.

The Valley of the Poting.

4.—The Poting valley enters that of the Gorigunga at Bugdiar, two marches north of Mansiari on the Almora-Milam road.[3]

[1] The point has been marked C_1 instead of C, on the sketch map of 1911.
[2] Diagram No. 13, Table B. 1.
[3] Indian Atlas, quarter sheet, 66.

A rough longitudinal section from Bugdiar to the glacier snout is given in sketch No. 8, from which it will be seen that the bottom of the valley, over this section, rises at about 570 feet per mile, but that the gradient is by no means even. There are two very defined bumps at the 2nd and at the 4th mile up from Bugdiar.

Variation in gradient of valley bottom.

A grazing track leads up the left bank of the stream. For the first two miles the gradient is steep, and the lower ption of the valley as far as can be judged from the path is steep-sided and V-shaped at the bottom; the Poting gár being even now hard at work cutting down through a great amount of talus swept down from the upper valley and also derived from the cliffs to the north. The general trend of the valley is here west and east.

5.—After 2nd mile and at an elevation of about 9,800 feet to 10,000 feet the valley opens out considerably, and the gradient is very much less steep.

An open part of valley: distribution of talus.

The general dip of the gneiss being more or less northwards and the trend of the valley roughly west and east, the stream keeps to the southern side and vast slabs of rock slope down to it from the southern bounding ridge, with only moderate talus at their feet.[1] There is, as is natural under these circumstances, much more talus on the northern side of this open part of the valley.

This latter is no doubt derived in a great measure by denudations from the cliffs to the north; probably the larger blocks constituting the rock falls seen about here are from these cliffs. But judging from the size and shape of the smaller boulders in this talus, and the very evident lines of distribution among them, it is probable that a large quantity of it is derived from hanging valleys high up in the northern cliffs. Probably a portion is originally of glacial origin. The whole mass has been much rearranged by water flowing from the north, and the usual long straight channels with steep sides have been formed in the boulder beds.[2]

6.—Sketch No. 11 shows the bearings of certain prominent points from the point where the valley commences to open out at 2nd mile from Bugdiar. From this the position of the valley of

[1] See sketch No. 11, round about the word "Jungle" just above "Poting Gár."

[2] There is a remarkable absence of earth between the boulders near the channels at the surface.

the small Cherkani glacier can be recognised.[1] The Poting glacier itself is first seen from this point.

In the centre of the open space which is next traversed a small Bhotia village now exists and one substantial stone house is being built.

At about the 4th mile the valley commences to rise again at a steeper gradient. This rise is also due to a mass of detrital matter very similar to that at the 2nd mile and lower.

There are many large blocks, possibly derived from the cliffs to the north, but here again the greater portion is composed of smaller sub-angular blocks set in earth.

There was, however, no time for close inspection. The whole is grass-grown and well established, and the stream here, as lower down at 2nd mile, is still cutting its way down through the mass.

7.—The camping ground used in 1911 was lower than that of 1906. It was situated some ½ mile below the snout.

The valley near the snout.

At this point the valley takes a turn towards the north, sweeping round into a straight run on a bearing of about 140° and 320° and some 2,000 yards long. It is in this straight run that the advance portion of the Poting glacier lies. The valley here is steep-sided and rugged;[2] but the bottom seems to be gently sloped transversely. After a run up this straight portion for 2,000 yards the valley takes a very sharp turn up to the north on a bearing of 9° and 189°. This portion of the valley is a deep cut, with very steep walls up to 300 to 500 feet above the ice, and holds the ice fall.

The general inclination here up the cascade is 31° from the horizontal.[3]

A description of the valley above this point is reserved till the névé is described.

The Glacier Snout.

8.—As mentioned above in Section 3 the ice cliff at the snout seems to have remained in practically the same position as in

[1] The valley of the small glacier marked on the Atlas sheet just south-west of Cherkani peak (17,088 feet) calls for remark when considering the evidence of the former extension of the glacier in this valley.

[2] The sides seldom slope at *less than* 30° from the horizontal and there are many cliffs on the north side.

[3] See photograph No. 14. The ice fall, taken from ⊙888′.

1906. There is some slight evidence of retreat, but this may be seasonal, as the measurement of 1906 took place in October and that of 1911 in June.

No evidence of a conclusive nature with regard to secular motion.

According to the plane table sketch of 1906[1] the Cairn of 1906 was built so that its centre lay some 10 feet back from the lip of the ice cliff; that of 1911 lay wholly within 3 feet of the lip.

The distance from ⊙B to the cairn of 1906 was 949 feet, and from ⊙B to the cairn of 1911 worked out at 960 feet, so there is a certain difference of 11 feet *plus* the probable extra difference of 7 feet making 18 feet of retreat at a *maximum estimate.*[2]

9.—The lip of the ice cliff is a very strongly marked natural feature and seems fundamental. It is quite a reliable line of reference. This is deducible from the very constant value of the slope of exposed ice (as observed in the Poting) when caused by weathering. It is always within a few degrees of 35° from the horizontal.

Lip of 1911, smaller than that of 1906 and slightly more up valley as a whole.

Sketch No. 2 shows the horizontal trace of the lip of the ice cliff of 1911 superimposed upon that of 1906, the latter feature being enlarged from the sketch map. pl. 65, *Records, Geological Survey of India,* Volume XXXV. The ice cliff of 1911 is seen to be somewhat smaller than that of 1906 and as a whole is further "up valley."

All that can be concluded from the above is :—

(1) The lip of 1911 is a few feet further up valley than that of 1906.

(2) The observed difference may be seasonal.

(3) If it be secular it is very small, being only 3·8 feet per year at a *maximum estimate* and it may be as low as 2·3 feet per year.

10.—The form of the ice cliff itself is worthy of remark. It is a surface of ablation rather than a cliff containing the usual cave. At the time of the visit of 1911 the lower portion was much hidden by snow, but the glacier stream could quite easily be heard a short distance from the snout and its position located by ear.

[1] *Records, Geol. Surv. Ind.*, Vol. XXXV, pl. 65.

[2] See diagram No. 2, which shows the lip of 1906 and that of 1911, superimposed on it.

Form of the ice cliff and ice cave.

From the photos of 1906,[1] and the observed slope and conditions of 1911, it seems that though a lot of sub-glacial drainage escapes from under the ice, there is no true tunnel-like ice cave of any considerable dimensions. Water trickles down at all points of the exposed surface and unites with the sub-glacial discharge to form the glacier stream.

Ice at the snout.

11.—The condition of the ice itself at the snout is very instructive and interesting. The ice is highly laminated. On close inspection the finer structure is seen to follow the more defined "ribbon-striping"[2] appearance, which is the most pronounced feature of the ice when viewed from a little distance. Generally speaking the structure, at the snout, dips inwards, up valley and towards the axis of the glacier; the angle of dip is, however, very small. Towards the south centre of the ice cliff and on the north side low down the dip is reversed, being down valley at a very small angle.

In other words the snout exhibits the well-known spoon arrangement of structure. The low angle of dip, and the above-mentioned reversal are, however, remarkable points, considering the short distance of the snout from the great ice fall.

It cannot be much more than 2,000 yards.

Ribbon-striping

12.—A point of considerable interest and difficulty presented by the ice at the snout and also at certain other parts of the glacier is the abovementioned ribbon-striping. It was observed at several places where the ice was exposed in steep faces near moraine, and was seen everywhere round the snout on crevasse walls and on the face of the ice cliff. This ribbon-striping closely follows the smaller *structure*, but unlike the latter is not lenticular in its parts as seen in section.

The whole ice surface where it exists is covered with fine mud and gravel and the stripes, seen in section, *look* like layers of the ice, which owing to some natural property hold more of the surface dirt than those contiguous to them. It may be, that the

[1] See *Records, Geol. Surv. Ind.*, Vol. XXXV, pl. 58, and compare with Shankalpa ice cave, pl. 57.

[2] This term "ribbon-striping" is used as a stop-gap until the true nature of this phenomenon is traced or it can be referred to some already known feature of the glaciers of other parts of the world or of the Himalaya.

mass of the ice itself contains more dirt in these layers; but this was not evident from a close inspection of the ice as seen in sections along several bearings at large angles to one another. The ribbon-striping, to all appearance, is simply an expression of the inner structure of the ice in terms of the outward dirt.

Ribbon-striping compared with dirt bands.

13.—So far as this goes they might be the usual well-known dirt bands, but there is much against accepting this as an explanation.

Dirt bands, according to Tyndall, are formed by dirt settling in the residual snow left in the trough of the wave-like wrinkles found at the foot of the ice cascade of many glaciers.

The orientation of the glacier bears a part in their origin. (Snow in the trough is, however, not always necessary for their formation.)

The ice as a whole becomes more rotten at these places and so retains a considerable amount of extra dirt to the end of its course.

There are five such wrinkles at the foot of the Poting cascade, but these must be about 400 feet from trough to trough, and it is hardly conceivable that by any of the usual processes of glacial movement they can have reached a distance of say 1 foot to 18 inches apart and have attained a uniform width of from 2 inches in some cases up to about 1 foot in others by the time they reach the snout some 5,000 feet from the foot of the last wrinkle (measured along the surface of the glacier).

Ribbon-striping noted close to the ice fall.

Moreover the ribbon-striped appearance was noted well up the glacier on the face of the small ice cliff in the right lateral moraine, which is itself at the foot of the last wrinkle.

Ribbon-striping and softer parts of veined ice.

14.—On the other hand it is hard to ascribe these stripes to dirt held in the more porous parts of the laminated ice. The lamination of the Poting glacier is eventually a lenticular arrangement. This being the case how can dirt held in the softer ice embracing lenticular parts of a clearer and harder nature give rise to long ribbon-like stripes on an exposed surface such as the ice cliff?

This is all the more improbable because, as will be described later, the *width* of the laminæ of both white and blue ice in the

veined portion of the glacier is small, never more than some 3 inches as a maximum at those points where it can be observed.[1]

Should the above be the cause of ribbon-striping we should expect the markings resultant from it to spread about on the ice face in a somewhat irregular manner like the veins on certain marbles; not, as is the case, to find regular, sharp-edged stripes all parallel one to another, each following the slightest flex in the general run of the structure.

Ribbon-striping and crevassing.

15.—Search was made to see if the ribbon-striping could be in any way connected with the crevassing. It might possibly be that the stripes were scars, or even layers, in the ice which were charged with more dirt than other parts, due to the fact that they represented healed up crevasses.[2]

No connection could be found. Indeed it seems very improbable that there can be any, especially in a glacier like the Poting, which is only 6,000 feet long below the cascade foot. Crevassing, for the very reasons that cause it, is *across* the structure except in those cases where it is subsequent to it. Under these latter circumstances, however, cross structure can generally be traced when the crevasses are marginal, or the origin and final fate of the crevasse itself is traceable in the case of transverse or accidental crevassing. In the Poting one case of transverse crevassing was observed running with the structure, but it was quite possible to see from the place itself that this could produce no general effect right across the snout such as the ribbon-striping is. On the other hand all other crevasses observed cut the structure at a large angle.

Under these circumstances it is hard to believe that the ribbon-striping can be directly due to healed crevasses.

Distribution of stones on surface of ice and in ribbon-stripes.

16.—There is no doubt that at the exposed surface the ribbon-striping contains more sand and dirt than the other parts of the ice there.

The ice is more pitted with small stones and small holes.

But as the stones increase in size there is a very marked and sudden change in distribution. They seem much more, indeed quite, evenly distributed over the surface.

[1] And not more than 18 inches long even as a maximum. (See section 34 on p. 119.)

[2] See *Jour. Asiatic Soc., Ben.*, Vol. XVI, 2, paper by General Strachey on Pindari and Kuphini glaciers.

In one place three sides of a column of ice carved out by cross crevassing were observed. Each ribbon-stripe followed the same plane, as it outcropped on these three faces.

The semblance to a pile of sandwiches of clean and dirty ice was very strong.

But on clearing away the surface ice and dirt over several dark and light stripes the ribbon-striping was no longer evident though the lamination was even more clear.[1]

Lamination at the snout.

17.—The lamination of the ice at the snout next calls for remark. Closely associated with the lamination is the graining of the ice.

Appearance like a compressed conglomerate.

At the snout itself the ice is in a somewhat different condition from that further up the glacier. The lamination, however, is distinct. The ice can be split up along the planes of structure with ease and the whole consists of lenticular portions of the ice separated from each other by more friable parts. But the ice seems to be in a different condition from that at the snout of Alpine glaciers. One cannot say it is truly *veined.* The lamination seems rather to be more abrupt and "short." Instead of large plates of clear blue ice included in white irregular bands the whole gives the impression of being a conglomerate of nodular concretions which has been subjected to intense pressure.

Graining of the ice at the snout.

18.—The graining of the ice a little higher up in the left lateral moraine is most marked and will be dealt with later.

At the snout this graining exists, but each grain is compressed, in the direction parallel to the general lamination, to a very much more marked degree than further up in the glacier.

Ice flowers not seen, but other evidence of planes of freezing noted.

The grains themselves, to a depth of at least 9 inches (and may be more) from the exposed surface, are separated from each other by capillary planes which seem to contain water. This is due to weathering preliminary to the melting of the whole. Individual grains were examined for ice flowers; none were found, but the trace of some molecular, or other, arrangement, was, nevertheless, to be observed in each grain.

[1] Time did not allow of a final experiment being made by trenching the ice on two parallel planes, close together, and across the structure. It might then be possible to see (by transmitted light) if the dirt in the ice tended to collect in certain planes or not.

These proved by the way that they ran in each several grain, that the grains themselves were set at random in the ice as in the case of Alpine and other glaciers.

This marking of the grains consisted simply of very fine lines, parallel to each other in each individual grain, which could be seen on the exposed surface when viewed at the proper angle.[1] In cases where the specimen was in an advanced stage of disintegration the finger nail could just feel the little hollow line caused by them.

Colour of the ice at snout in hand specimens.

19.—The ice itself when viewed in hand specimens is clear as crystal, showing no colour of its own, though the usual prismatic ones (chiefly violet) are often seen in turning it. In spite of this clearness in small specimens, the ice as a whole is highly charged with gravel and dust. The grains of gravel are quite visible when the ice is looked close into *en masse*; the grains seemed to be scattered at random, as also is the case in hand specimens. The ice also contains much exceedingly finely divided rock matter such as is commonly to be obtained by straining the water of glacier streams through filter paper.

Ice charged with gravel and dust.

The very finely divided matter present in the ice.

A very remarkable point about this fine dust is that the ice charged with it when unmelted looks clear, the dust does not show, only the larger grains of gravel and sand are visible. When, however, ice from the snout is taken, cleaned outside, dried and melted, the water obtained is quite muddy. So much so that a white glass quart bottle full of it quite obscures the light from an ordinary candle held only 3 inches on the further side of the bottle from the eye.

So fine is this matter that after the bottle has been well shaken up and then allowed to stand for 72 hours some of it is still suspended in the fluid.

Amount of foreign matter in the ice at the snout.

20.—In order to obtain some idea as to how much foreign matter the ice contained a specimen was taken from the snout, cleaned, dried, and melted in a carefully prepared vessel, the proceeds being poured into a specially prepared bottle cleaned by a chemist

[1] By holding hand specimens of ice at various angles to bright sunlight it was hoped that some more of the internal structure of the ice might be shown up by reflection. But nothing more was seen.

and kept corked till wanted.[1] While melting the ice was closely watched for bubbles, but no traces of air were seen rising through the water.

One bright silver-like spot was seen; it was not flat, but was of the shape of an ordinary raspberry. It was, however, only some ⅛ inch in diameter. On gently rubbing the ice till the finger touched this, the whole vanished like a flash; it was probably vacuous, but it is impossible to say for certain. The rubbing did not take place under water, but a thin film of water covered the ice at the time.

21.—The actual spot from which the specimen was taken was the roof of a small cavity, formed during melting, about half way down the face of the ice cliff.[2]

From the roof and sides of the cavity nodular masses of ice were hanging. Several of these were broken off by hand and melted.

Nodular formation of ice when melting.

This nodular formation is remarkable. It seems to be due to the ice melting from the surface of each *grain*, and shows how very strongly the granulation governs the disintegration of the whole.

As examined here the white ice which is found embracing the blue plates in cases of ordinary lamination was absent. The fact that no bubbles were seen to rise as the ice melted is significant. Experiment on a larger scale may, however, prove that air is present, but on a very much more reduced scale than is usually the case. Unless this is so, or some other substance, or condition of ice, is substituted for it, how is it that the fissile quality of the ice along well marked and visible planes still remains? The whole should unite as one mass by regelation.

Colour of ice at snout *en masse*.

22.—The colour of the ice at the snout as seen *en masse* is very noticeable. When seen from a few inches the ice is clear, the sight plunges down into a dark void slightly tinged with tea colour. But when seen from a little distance the ice looks slaty grey; not unlike the colour of the flanks and sides of an ordinary grey donkey.

[1] This was found to contain—

(*a*) A light sediment 0·5 per cent. consisting chiefly of clay and soapstone [including the small quantity of dissolved matter].

(*b*) A heavy sediment 0·8 per cent. consisting of course siliceous sand and fragments of various stones.

[2] See Sketch No. 9A (diagrammatic).

The ribbon-stripes are of the same colour, only a tone or two darker.

When seen from close up the stripes have a slightly more brownish colour than the rest.

Taken as a whole, when viewed from some 200 yards, the ice looks not unlike the lighter portion of the surrounding rock of the valley.

Complete change in general appearance of ice under certain lighting.

23.—Under one particular lighting there is a complete change in appearance. This was first noted at 2-30 P.M. on June 7th in bright sunlight. The observer was some 100 yards east-north-east of the snout and some little distance below it in level. The ice cliff under these circumstances looked white with grey ribbon stripes running across it. The ribbon-striping was extraordinarily clear and with sharply defined edges. This appearance was maintained till the observer had approached quite close to the ice, say some 30 or 40 yards and then on approaching still nearer it vanished quite quickly within a zone of about 10 paces (the observer approaching up a slope the whole time). It is very probable that this white appearance is due to light reflected from some of the inter-granular capillary surfaces mentioned above.[1]

The position of the sun and the eye with reference to the observed surface are auxiliary factors determining the point at which the appearance vanishes.

Once observed the appearance can generally be seen again by dodging about till the correct angle of view and distance are obtained.

24.—The fact that there is a limiting zone, for a given position of eye and sun, points to probable reflection from some particular *set* of capillary planes more or less parallel one to another.

This tends to confirm the observations already made that the lamination has the appearance of a compressed mass of nodular concretions[2] and that the grains themselves (at the snout) are compressed[3] in the plane parallel to the general lamination.[4]

[1] See section 18 above.

[2] See section 17 above.

[3] See section 18 above.

[4] The white appearance was not *bright, i.e.*, not like the light reflected from a wet or polished *surface*, but was dull white like some ice in the cascade.

No large boulders were noticed included in the ice at the snout, though some fair sized stones were seen, say 3 to 4 inches in diameter. These were embedded in the ice and may simply have sunk in at the surface, being large enough to store heat for the work.

These stones were angular fragments, not scratched or smoothed.

The Terminal Moraines.

25.—No terminal moraines other than those in the immediate vicinity of the snout were seen. These seem much in the same condition as in 1906.

In June 1911, snow below the snout prevented search being made for scratched boulders.

The small terminal moraine marked in the sketch map of 1906 [1] at a point 300 feet east of the last "S" in "LARGE CREVASSES" has considerably developed since 1906;[2] it can now be traced right up to the ridge of the active left lateral moraine.

No cracks in terminal moraine.

The newly formed and the old terminal moraines were searched for cracks which might indicate an advance of the snout. The moraine at the north-east corner of the snout was sufficiently exposed to show any had they existed. Not the slightest trace of any such cracks was found, though here, as elsewhere, a certain amount of fresh moraine matter was found shot out over the old moraines near the ice. On the older moraine, bushes and short under-growth some 2 or 3 inches high are firmly established.

Some new moraine matter shot out over old terminal moraine.

The Left Lateral Moraine.

26.—The left lateral moraine is the most interesting member of the glacier. In June 1911 it showed very considerable signs of activity. Looking up the cascade the extra amount of moraine matter brought down it on the left (east) side was very marked when compared with the right. Large blocks with intruded veins, as in 1906, were of frequent occurrence and were noted

Extra moraine comes down left side of cascade—large blocks frequent.

[1] Plate 65 of *Records, Geol. Surv. of Ind.*, Vol. XXXV.
[2] Eye estimate from plate 65 and photo of snout, plate 58, *Records, Geol. Surv. of Ind.*, Vol. XXXV.

all along the ridge of this lateral moraine from Cascade Point right down to the snout.[1]

At the foot of the cascade the ice is seen to be considerably higher on the left (east) side and this bulge sweeps round into the straight run of the left lateral with a very energetic curve. This, however, is in a great measure due to the plough action of the western face of "Cascade Point" cliff, which is highly glaciated as a consequence.

Sketch No. 3A shows the type of the left lateral moraine down to about point 960 feet. Sketch 6 shows the transition stage at 960 feet, and sketch No. 3B shows the final resultant type below that point. The protection afforded to the ice of the moraine causes the usual elevation of the ice under it; the outer face of this elevation is a steep slope of ice at 35° from the horizontal.

New moraine matter shot over older wall of left lateral moraine.

27.—The rocks, etc., shot down this slope are to a great extent caught up in the crevassed ice between the slope and the crest of the old grass-grown moraine wall; but not all. A very considerable amount, all along the moraine from Cascade Point onwards, is being shot out over the upper slopes of the old moraine wall. This new stuff shows up very raw and clear against the older grass-grown material below it. Below point ⊙960[2] the active left lateral moraine looks as if it were about to ride over the old moraine wall.

Set of current tending to override left lateral moraine.

The fact that there is a very distinct set of current in the ice tending to bring this about is very strongly forced on the mind when this point is observed from a little west of, and above, ⊙A.

The evidence afforded by the crevassing and structure near this point strongly bears this out. The apex of the structure is abnormally close to the left lateral moraine just about this locality. This will be dealt with later on. It is, however, worthy of recording here that the evidence given by the crevassing, etc., was not clear till the interpolated points and the strike of crevassing had been plotted, which was done away from the glacier and so is in a great measure independent evidence.[3]

[1] The intruded and folded veins as exposed in the peak shown at the head of the ice fall in photo (14) are exceedingly beautiful. The blocking out of this peak by denudation regardless of the folding is very characteristic.

[2] See sketch map No. I.

[3] See sketch No. 12.

28.—No one in the present state of the glacier would be so rash as to say the active left lateral moraine is about to ride over the moraine wall. But the conditions which make such a thing possible are present. The fact that the melted ice has already commenced to drain down the moraine wall east of ⊙960 [1] is significant.

Drainage down flank of moraine wall.

This may eventually cut a channel of sufficient size to allow of a small ice flow down it. Should this happen the Poting glacier will be a very interesting one to watch closely. Evidences to what happens when ice flows over loose boulders and old moraine matter is always very well worth collecting. Observations from ⊙960 were taken to determine the height of the ice relative to the side of the valley at this point.[2]

29.—The following points were noted with regard to the ice in the left lateral moraine at a point 250 yards up valley from the snout.[3] (The moraine at this point is mainly composed of rough broken stones 3 inches to 1 foot in diameter. The depth is very variable but probably never more than 3 feet.)

Ice in left lateral moraine near snout.

The ice is highly granular, clear in hand specimens, and not of a dark green colour.[4] The grains show the capillary planes between them very distinctly. The grains average $3'' \times 3''$ to $\frac{1}{4}'' \times \frac{1}{4}''$, but there are not many smaller than the latter: they contain sand and gravel up to $\frac{1}{8}$ inch in diameter.

The fine lines in each grain were noted here as at the snout. The arrangement is exactly similar. The lamination of the ice is the same as at the snout; only the compression of each individual grain with the structure is not so pronounced. Further up valley, about 430 yards from the above point, the ice is different.[5] The lamination is of a much more normal type, white bands include lenticular plates and the graining is not evident. The blue plates are up to $1\frac{1}{2}$ inches thick and the white ones up to 2 inches. The laminæ of blue ice are, however, "short" here as elsewhere in this glacier.

Ice in left lateral moraine near bend of glacier.

[1] See the two arrows on sketch map No. I.
[2] See "Ice level block" on sketch No. 6.
[3] Sketch No. 12, point II.
[4] Some glacier ice in Kumaon has been described as "dark bottle green."
[5] Sketch No. 12, point IX.

The Right Lateral Moraine.

30.—Owing to the amount of snow about, the observations made on this member were very few.

As far as the conditions allowed it to be traced, it appears that the moraine matter which comes down the right side of the cascade forms an active lateral moraine inside the older right moraine wall. It keeps close to this latter all the way down the straight run to near point ⊙935. The snow here was deep; but a series of mounds projecting from it and running on a curve gradually receding from the moraine wall was noticed. This is believed to represent the present right lateral in this part of the glacier.

From a combination of the facts observed in 1911 and those deducible from the photographs of 1906 [1] it seems that from the great bend onwards a new moraine wall is now being formed inside the old one on which the points ⊙821, ⊙337 (D) and ⊙229 (C) are marked. It is in a very embryonic stage. Short vegetation is firmly established on the old moraine wall. No new moraine matter was observed shot over the old in this lateral. Larger blocks are few and far between and none were observed which looked newly deposited.

No detailed observations on the ice of this member were made. Where seen it was similar to that in other parts of the glacier in the same transverse zone.

Auxiliary ice cliff in right lateral moraine.

31.—The formation of a small auxiliary ice cliff well up in the right lateral moraine is interesting.[2] This occurs just at the foot of the last of the 5 wrinkles at the foot of cascade. This is a point where a general change of slope takes place right across the glacier.[3]

The buttress of rock which meets the right lateral moraine at this point has probably (by the combined action of retardation due to friction and thermal effects due to retention of heat by the rock) been the main cause of the formation of this cliff. A very considerable amount of drainage takes place from under and down the face of this cliff. It keeps inside the old moraine wall and finally joins

[1] See *Records, Geol. Surv. Ind.*, Vol. XXXV, pl. 58.
[2] See sketch map No. 1 at a point in the right lateral 1,500 feet south of cascade point (2038).
[3] See sketch No. 7 at 1,730 feet from cascade.

the main glacier stream near the snout. The exact manner in which this drainage is conveyed was not observed. The slope of the face of the ice cliff was not measured: but it was estimated at about 35°.

Sketch No. 16 shows the arrangement of the structure as shown at this point. *c*, *c* are crevasses[1] and *s*, *s* indicate the structure. To those interested in the folding of natural substances this sketch is instructive, as it shows an instance of the folding of the ice into a wedge, which has been driven up through the structure on one side of and above it. The wedge remains clearly marked and sharp, but the structure of the ice into which it has broken is quite destroyed for some 1 to 3 feet around it.[2]

The Surface Moraine.

32.—The snout is covered right across from side to side by surface moraine, which has in places given rise to glacier tables and sand cones.[3]

Sand cones.

Sand cones resembling a hog's back were observed some 900 feet west of the ice cave. The larger stones on the sand cones had sunk into the ice in the usual manner. The orientation of the major axes of the hog's back sand cones was not taken with the compass, but is more or less west and east. At the snout itself small sand cones on the actual slope of the ice cliff were of frequent occurrence. They were about 2 feet high and some 3 to 4 feet across the base. These were ordinary cones.

One glacier table was measured up, at the point marked G ⊙ T 900 feet west of ⊙ 293 (the cairn of 1911). It was a block of light coloured gneiss 8′ × 6′ × 4′ on its flat. It dipped at 15° from the horizontal towards MB 170°.[4] The stem was some 3 feet high and 3 to 4 feet thick. The ice in it is clear, charged with gravel and granulated. No note was taken of the direction of lamination. The grains were noted as smaller than at the snout, averaging from $\frac{3}{4}'' \times \frac{3}{4}''$ to $\frac{1}{4}'' \times \frac{1}{4}''$.

[1] See sketch No. 9 B for type.

[2] Ribbon-striping was observed following the structure in this ice cliff. It was not so broad as at the snout.

[3] This moraine varies from 1 to 3 feet in depth.

[4] The slew of 10° in this dip is due to an afternoon shadow from the ridge on the south-west side of the glacier.

33.—The area round point G ⊙ T was examined for structure. It is very heavily crevassed. The structure is of very much the same type as at the snout.[1]

It is interesting to note the distinct tendency there is (shown by the plotted results of dip and strike round here) for the ice in the left lateral moraine to "set" outwards [2] just below ⊙960′. The exact distance up the glacier that the surface moraine extends was not determined, on account of the prevalent snow drift. At ⊙943 there is no surface moraine of any consequence. The snow here was only 1 or 2 inches deep and on sweeping it away the wel lknown "rake marks" were seen. In the crevassed areas west of G ⊙ T moraine is heavy. The western limit of it may be estimated at somewhere about 600 to 700 feet west of G ⊙ T.

Extension of surface moraine up glacier.

Near ⊙ 943 a very careful search was made for ribbon-striping. A series of crevasses were examined in great detail here, from newly formed ones only a few lines wide to ones which had opened out to 6 to 9 inches wide and more and into which it was possible to see for from 5 to 15 feet.

No ribbon-striping seen in centre of glacier above area of surface moraine in newly formed crevasses.

Not the slightest trace of ribbon-striping was seen either on the crevasses or on the ice surface.

34.—The structure of the ice as seen here was of a much more normal type. It consisted of the usual lenticular plates of blue ice enclosed in that which was white and more friable.

Structure of ice near ⊙960.

The greatest length of the blue plates did not, however, exceed about 18 inches and many were shorter.

Grains were not observed in the ice here. Probably the ice had not been sufficiently exposed to weathering to develop them. The amount of sand and gravel in the ice seemed much less than at the snout, but no numerical test per given area was made.

No grains visible near ⊙960.

The Crevassing.

35.—The crevassing at the margin of the glacier on both sides is quite of the normal type from the cascade down to the

[1] For dip and strike of structure, etc., see sketch No. 12.

[2] See above section 27.

bend at ⊙943. No transverse crevasses were observed in this part of the glacier. If there were any they were quite hidden by snow.

Crevassing of the normal type.

At the base of the cascade there were the usual minor longitudinal crevasses, arranged in the well-known fan-like manner. These indicate the strains set up by the spread of the ice at this point.

The complicated system of marginal, longitudinal and transverse crevasses developed below ⊙943 is interesting. It is quite impossible to describe this system in words, but the general outline of it can be indicated by diagrams.[1]

Crevassing at and below bend.

No observations could be taken on the diurnal motion of the ice, but from the observations on the crevassing and structure as shown in sketch 12 and map 1 it appears that the ice near the left lateral moraine flows somewhat quicker than that in the right down to the bend; from there onwards the right side gains and the point of greatest velocity migrates towards the convex side in the usual manner.

Normal longitudinal crevassing.

36.—The retardation on the left side and the associated longitudinal crevasses near point VII, sketch 12,[2] are quite according to what is known of crevassing in other glaciers. One component of the spreading motion consequent to the above has probably been the cause of the set of the ice current towards the moraine wall north-east of ⊙960 mentioned above.[3]

Transverse crevassing near G. T.

The crevassing just west of G ⊙ T is believed to be *transverse,* not longitudinal. The probable cause of it is a change in level of the valley bed, or perchance unevenness due to ridging from the south. The system has, however, become so complex near here that it is not possible to say for certain.

"Scaling off" at snout.

37.—There are two minor forms of crevassing which call for notice. Firstly, the type seen at the snout in the face of the ice cliff, parallel to the structure and dip, and of the nature of a scaling off rather than a type of true crevassing.[4] In the Poting this scaling off seems to

[1] See sketch No. 12 and crevasses on sketch map No. 1.
[2] Just south of ⊙960 on sketch map No. 1.
[3] See sections 27 and 28 above.
[4] See sketch No. 9 A.

be due to the weight of the ice itself coming into play as the sub-glacial drainage undermines it.

Judging from the photos taken in 1906 by the Geological Survey, it seems probable that this scaling off can be brought about by any thrust along the planes of lamination tending to crumple up the ice along these lines.[1] The difference of the nature of the crevassing in an ice cliff where the structure outcrops in a different manner from that above, is seen in the small ice cliff in the right lateral moraine.[2] Here the structure is more or less vertical and longitudinal, and the crevassing consequently takes the form of step faulting.

Different resultant crevassing in small ice cliff.

38.—Associated with the transverse crevasses near the point G ⊙ T are a few true faults in the ice. Sketch No. 10 illustrates an example of a trough fault at this point.

The actual surface of the glacier shows no change of level where this occurs. But the fault lines are clear and the throw of the fault can be roughly estimated from the displacement of the lines of lamination and of ribbon-striping.

The small trough along the ridge of ice formed in this instance is an interesting feature.

Near ⊙943 the crevasses are newly formed and contain no moraine stuff. At G ⊙ T the moraine stuff fills them to within 6 to 10 feet of the lip; at the snout they are filled to the lip, and the surface moraine surrounds the crevasse in the form of a sort of crater, the sides of which slope at some 30° to the horizontal.

Moraine stuff fallen into crevasses.

39.—As can be seen from the cross-sections given in sketch No. 6, there is a distinct trough formed on each side of the glacier inside the ridges of the right and left lateral moraine.

The medial swell is not as high as the left lateral moraine when the cross-section is taken at right angles to the general run of the glacier at ⊙943. The commencement of this trough was not exactly noted on the right side of the glacier.

[1] See *Records, Geol. Surv Ind.*, Vol. XXXV, pl. 57.
The arching in this case tends to support the ice above it and the splitting is due to breakdown under the spandril thrust, such as may be seen in the cases of some badly built brick bridges.

[2] See sketch No. 9B.

On the left side it commences some 1,000 feet to the north-west of ⊙960 and is much augmented by the longitudinal crevasses near ⊙960, which no doubt allow of a greater amount of weathering action on the ice than would be the case if they did not exist. Much of the surface drainage finds its way down this trough and the associated crevasses. The form of the trough is obliterated amid the great crevasses north of G ⊙ T.

The trough inside the right lateral moraine contains a certain amount of surface drainage, which combining with the sub-glacial drainage on that side probably gives rise to the small stream marked inside the end of the right lateral moraine on plate 65, Vol. XXXV, *Records, Geological Survey of India.* Snow prevented this point being determined by accurate observation.

The Ice Fall.

40.—A photograph of the cascade[1] shows that it is very much narrower than the "Flowing Glacier" below it. The general slope of the fall is 31°, measured up the mean slope of the ice surface.

The following notes were made on the ice in the cascade.

There is a distinct tendency to split on radial lines at the foot of the cascade. The waves at the foot were covered with snow, but looked distinct enough.

Blocks of ice shot down from the upper portion of the cascade show distinct structure, and (owing to weathering after fall) show the granulation. They contain no visible sand or dirt. Moraine descends on both sides of the cascade: that on the left is in greater quantity. Large blocks were seen 100 or 200 paces from the foot of fall in the left lateral.

41.—The ice is generally white in colour, but a faint glimmer of blue was noticed about ⅓ way up the fall.

There seems to be a more or less horizontal portion in the fall half way down and the structure developed there can be noted in the ice in the lower portion of fall.

In the top of the fall the ordinary horizontal stratification of the névé just where the field breaks into the first séracs was beautifully clear as seen with field glasses.

[1] Photo No. 14.

The Névé.

42.—No close examination of the névés was made, as frequent avalanches made approach difficult and time did not admit of reconnaissance for a safe route.

The névé has been visited by one climbing party (Dr. Longstaff). It appears to be of a normal type, the only remarkable features being the great steps across it,[1] which appear to radiate from the peaks on the north bounding ridge. The lowermost of the walls thus exposed showed the stratification of the névé very clearly. The approximate gathering area above the top of the ice fall is some $5 \times 1\frac{1}{2}$ miles in area.

Evidence as to Former Extension of the Ice.

43.—The Poting valley offers several points worthy of investigation under this heading.

The shortness of the visit of 1911 rendered it quite out of the question to do more than note a few localities which looked as if they would repay future investigation.

Warning to future observers.

One warning to future observers is also needed. In many places on cliffs composed of the gneiss developed in this area, the eye is attracted to rounded bosses of rock which look very like ice-worn ones. But very frequently a closer inspection proves that the rounded surfaces of these bosses are really due to exfoliation of the gneiss in huge plates, and the subsequent further polishing of the surface by stones, sand, and water, shot down from hanging gullies and chutes during storms. The effects of perspective and great height above the observer frequently mask the true lines of projection of the stones, etc., and give a false appearance of glacial action.

44.—In the cascade itself, the walls (especially near "Cascade Point") are highly glaciated to some considerable height above the present ice surface in places.

Apart from this there is no evidence, at present visible, of a greater level of ice in the Poting glacier at some former period of

[1] See sketch diagram No. 15. This sketch is very diagrammatic and only shows main feature very roughly indeed.

the present epoch. The Cherkani secondary glacier, however, tells quite a different tale. Sketch No. 15 show (very diagrammatically) the most striking features of this little glacier valley. The valley is very evidently a hanging one, and the contours of its sides right up to its débouchment into the Poting valley itself are without doubt typically glaciated. The deep cut made by the glacier stream itself in the floor of the valley near its end also strongly supports the theory that the valley has been occupied by ice very much further down than is at the present the case, at a quite recent geological period.

Evidence of former extension of Cherkani glacier.

This hanging valley very much resembles that of the Lower Grindelwald glacier in general shape, though probably not in size.

TABLE I *a*.

Bearings taken with Prismatic Compass (corrected for centering error of instrument).

A to B	$153\frac{1}{2}$	B to A	$333\frac{1}{2}$	C_1 to A	$1\frac{1}{4}$	D to A	$9\frac{1}{2}$	K to A	$12\frac{7}{8}$
A to C_1	N.O.	B to C_1	$234\frac{3}{4}$	C_1 to B	$54\frac{3}{4}$	D to B	$54\frac{3}{4}$	K to B	$87\frac{1}{2}$
A to D	$189\frac{1}{2}$	B to D	$234\frac{3}{4}$	C_1 to D	$234\frac{3}{4}$	D to C_1	$54\frac{3}{4}$	K to C_1	N.O.
A to K	$192\frac{7}{8}$	B to K	$267\frac{1}{2}$	C_1 to K	$329\frac{1}{4}$	D to K	$2\frac{7}{8}$	K to D	$182\frac{7}{8}$

(*a*) Bearings 0° to 360° from north *viâ* east and south.

(*b*) The magnetic meridian as shown by these bearings differs from that shewn on the sketch map, plate 65, Vol. XXXV, *Records, Geol. Surv. Ind.*, even when allowance is made of change in variation between 1906 and 1911.

According to the chart to face page 82, *Hints to Travellers*, Edition VIII (1901), the variation in this district is decreasing at a rate of from 2 to 3 mins. of arc per annum. So at a maximum estimate, between October 1906 and June 1911 the change is about 14′.

TABLE I *f*.

	Measured from pl. 65, Vol. XXXV, *Records*, 1906.	From above table of 1911.	Variation, 1906–1911.	Residual Δ.
			Decrease.	
From A to B . . .	156½	153½	¼	2¾
„ B to C_1 . . .	237½	234¾	¼	2¾
„ C to A . . .	4½	1¼	¼	3
			Mean .	2·83

NOTE.—So the 1911 azimuths show a rotation of about 3° in a negative direction from the meridian accepted in 1906.
The reason of the difference is not gone into further. it is very possibly due to differences in the initial error of one or both compasses.
On the sketch map all have been reduced to meridian of 1906.

TABLE II *a*.

Angles observed with Box Sextant.
Means of from 3 to 7 shots each. (Index error ± 0′.)

K B A	65° 6·1′	A D B	46° 14′	A K B	73° 59·1′	B A D	37° 43·3′	K C_1 A	33° 14·4′
K B D	31° 5′*	K D A	7° 7′	B K D	95° 35·4′	D A K	3° 17·6′	A C_1 B	54° 47′
A B D	96° 6·3′								

NOTE.—These sextant angles are not horizontal. They are all taken 'in the plane.'
* 31° 5′. Every other observation taken goes to prove that this angle has been wrongly booked—it was probably 31° 35′ and that value has been accepted in working out the results.

TABLE II *f*.

Vertical angles observed with Clinometer corrected for index error.

A to B	—6¼	B to A	+ 6¼	C to A	U. O	D to A	— 5	K to A	—5½
C_1	N. O.	C_1	+15	B	—15	B	—15½	B	—16¾
D	+5	D	+15½	D	N. O.	C_1	U. O.	C_1	U. O.
K	+ ½	K	+16¾	K	+7¼	K	— 4¾*	D	+4¾*

* *Unreliable*; the value 4¾ seems to be the most probable one, but it has been "cooked" in addition to applying index error.

EXPLANATION OF PLATES.

PLATE 19.—Fig. 1.—Sketch map of the Poting glacier, 8th June 1911.

PLATE 20.—Fig. 2.—Horizontal trace of the lip of the ice-cliff of 1911, superimposed on that of 1906.

" 3.—Type cross-sections across ridge of left lateral moraine, above and below ⊙960.

" 4.—Rough sketch showing Ice Level Block as seen from the point ⊙960, 8th June 1911.

" 5.—Shape of ice-cliff, June 1911.

PLATE 21.—Fig. 6.—Section across the Poting glacier, 7th June 1911.

" 7.—Longitudinal section of Poting glacier from foot of cascade, 7th June 1911.

PLATE 22.—Fig. 8.—Rough longitudinal section from Bugdiar to the glacier snout.

" 9.—Types of crevassing.

" 10.—Trough fault in the ice.

PLATE 23.—Fig. 11.—Sketch showing bearings of certain prominent features from point where the valley commences to open out at the 2nd mile from Bugdiar.

PLATE 24.—Fig. 12.—Retardation of the ice in left lateral moraine.

" 13.—Diagram showing the exact position of K, the cairn of 1911.

" 16.—Sketch illustrating formation of an auxiliary ice-cliff.

PLATE 25.—Fig. 15.—Diagram showing the features of the Cherkani glacier valley.

PLATE 26.—Fig. 14.—Poting ice-fall from ⊙888, 7th June 1911.

" 17.—Snout of Poting glacier from ⊙ and C′, 7th June 1911.

MISCELLANEOUS NOTES.

Notes, recorded in August 1911, on Some of the Lakes of Ladakh.

(1) *Salt Lake.* Longitude 78°, latitude 33° 20.

Approaching from the direction of Debring I passed round the east side of the lake. Tried at several points to launch my boat, but nowhere was there a depth of more than six inches to a foot of water, beneath which is soft black mud. Waded into the middle of the lake: Drew [1] heard of a depth of 30 feet at the eastern end, but the old 'kardar' of Rukshu, who remembers Drew, says the lake has always been at its present level. Round the edges of the lake is a grassy swamp in which springs of fresh water are found. There was one near my camp at Knangur, the water of which had a rather unpleasant mineral taste.

The salt is collected this year by a contractor. I questioned his servant as to the depth of the lake. He said it was the same depth throughout.

(2) *Fresh water lake.* Longitude 78° 5′, latitude 33° 15′.

Found a depth of 10 feet in the middle. The bottom is full of weed. Water flows into the Salt Lake. Bay leading towards the Salt Lake is very shallow. The marginal marks are very distinct. I had no means of measuring their height.

(3) *Tso Kyagar.* Longitude 78° 25′, latitude 33° 5′.

Camped at the south end of the lake. Drew [2] assumes that this lake was once part of the same valley as the Tso Moriri. It appeared to me that the original exit of the Tso Kyagar must have been at the north-east corner where a flat of sand and gravel extends for about two miles to a gorge, which in its turn opens into the stream marked on the survey map as Chuldi, which flows into the Indus. I was unable to visit the spot, but with a telescope from my camp saw what looked very like an old moraine blocking the gorge from Tso Kyagar.

In view of Drew's description of the lake and his being unable to account for the confinement of its waters, the point would be worth investigation by a future visitor.

[1] *The Jummoo and Kashmir Territories*, p. 299.
[2] *Idem*, p. 309.

I took the following soundings on a line through the middle of the lake from north to south :—

	Feet.
50 yards from north shore	4½
100 do. do.	8½
200 do. do.	14
¼ mile from do.	18½
One-third of the way across	15
Half-way do.	35
Two-thirds of the way do.	45
½ mile from south shore	61
¼ do. do.	68
300 yards from do.	69
150 do. do.	61
100 do. do.	36
50 do. do.	25
20 do. do.	15
10 do. do.	8

The length of the lake is about two miles. If my theory of the formation of the lake be correct I am unable to account for the deep hollow at the south end.

There is a fresh water spring near the water's edge at the south end of the lake and several others round the lake. The water of the lake is slightly brackish and blue in colour. Some salts are deposited on the western shore.

(4) *Tso Moriri.* Latitude 32° 45′ to 33°, longitude 78° 25′.

Took the following soundings :—

(*a*) From Karzok due east to Lapgo :—

		Feet.	
50 yards from Karzok shore		58	
¼ mile from do.		151	
½ do. do.		157	
1 do. do.		193	
1½ miles from do.	(middle of lake)	240	approximate.
2 do. do.		240	
1 mile from east shore		163	
½ do. do.		103	
¼ do. do.		66	
200 yards from do.		18	
100 do. do.		10	

(*b*) From shore in middle of Umlung Bay to cape at south-west corner of Umlung Bay :—

	Feet.
100 yards from shore	23
200 do. do.	36
Middle	130
300 yards from cape	210
100 do. do.	132

(*c*) In the bay between two promontories on the east shore—

	Feet.
30 yards from north side	33
Half-way across	157
100 yards from south side	253

The island upon which Drew landed, and which he describes as being of gneiss and rising nine or ten feet above the water, is now completely submerged, showing that the waters of the lake have risen at least 9 or 10 feet since Drew's visit.[1] I could not make out from the peoples' description whether the island had disappeared gradually or in the last few years only. It would appear probable, however, from the analogy of the island in the Pangong Lake, that the rise of the water has been considerable in the last two years. I should be inclined to put it down to excessive snowfall rather than to decrease in evaporation. Marginal marks did not seem to be more than 15 feet above the present level of the lake, but I had no means of measuring. Drew gives them as 40 feet.[2]

It will be noted that some of my soundings differ from those of Drew. It is unlikely that we steered the same course in collapsible boats.

The water of the lake is a deep blue in colour and slightly brackish. In one place I saw a small fish near the surface which my Ladakhi companion recognised as what they call in Ladak "senrrya."

(5) *Pangong Lake.* Longitude 78° 30′ to 79°, latitude 33° 40′ to 34°.

I took the following soundings :—

(*a*) Merak promontory to promontory opposite—

	Feet.
100 yards from south shore	90
¼ mile from do.	112
½ do. do.	144
Half-way across (¾ mile)	150
½ mile from north shore	150
¼ do. do.	162
200 yards from do.	120
50 do. do.	112

(*b*) Mun to promontory opposite—

	Feet.
100 yards from south shore	33
¼ mile from do.	108
½ do. do.	114
Half-way across	156
½ mile from north shore	174
¼ do. do.	174
200 yards from do.	174
50 do. do.	80

[1] *The Jummoo and Kashmir Territories*, p. 306.
[2] *Idem*, p. 305.

(c) North-east corner of lake to Yaktil :—

			Feet.
50 yards from north shore			84
100	do.	do.	108
¼ mile from		do.	132
½	do.	do.	78
¾	do.	do.	132
One mile from north shore (½ mile from south shore)			126
200 yards from south shore			66
100	do.	do.	66
50	do.	do.	30

The bay opposite Merak contains a succession of beaches extending up to about 50 feet above the lake. Below is shingle; above it a hard conglomerate cliff about 4 feet high, then shelving shingle, then a cliff of travertine about 8 feet high, then shingle, then conglomerate, then shingle again, and above all a green shale.

Riding from Merak to Mun I saw the marks mentioned by Drew in the footnote to page 324 of his book. They are indistinct and not continuous. From Mun I searched the hillside with a Zeiss glass and could not make out the marks. I think what one sees from the promontories south-east of Mun are not marginal marks, but accidents of denudation give the impression of marginal marks.

On the north side in the bay opposite Mun are beaches of travertine on which lie flattish stones, some of which are 2 to 3 feet in diameter. Similar stones cover the floor of the lake round the edges.

The rock opposite Yaktil at the north-west end of the lake is now invisible or rather from the north shore I could just make out the tip of it with my field glasses. I landed on this rock in 1909 and it stood 5 or 6 feet out of the water then. The lake must therefore have risen to that extent since 1909, which fact may, I think, be ascribed to the heavy snowfall of the last two and particularly of last winter. The colour of the Pangong water is a deep blue and it is distinctly salt to the taste.

Drew and others have suggested that Pangong Lake, as well as the Salt Lake and Tsomoriri, have been formed by the alluvial fans from side valleys crossing the main valley and forming a dam.[1]

I do not feel competent to pass an opinion on the evidences of glaciation observed and described by Ellsworth Huntington,[2] from

[1] Both R. D. Oldham and Ellsworth Huntington dissent from this view.—ED.
[2] *Journal of Geology*, Vol. XIV, (1906), page 606.

which he deduces that the exit from the Pangong valley is closed by a rock lip. It does, however, seem possible that he underestimated the carrying power of what he calls the small tributaries. Some of these, although comparatively dry for the greater part of the year, may be considerable streams at the time of the melting of the snows. And even then a false idea of their energy may be obtained unless they are seen at a certain time of day. I have seen an insignificant stream suddenly become an impassable torrent so late in the day as 6 P.M.

It is then possible that a tributary may be at its greatest activity at times when the main stream is not. At such times it may be flowing with greater velocity than the main stream and may form accumulations which the main stream cannot carry away.

This process may be seen in other parts of Pangong and Rukshu, a country where there is excessive denudation of the surface and strong freshets in the spring while the snows are melting. Marching from Chushal to the Pangong Lake a huge fan with a radius of some three miles is crossed. It comes from the high range northwest of the Pangong Lake and has pushed its way almost across the Chushal valley, the Chushal stream finding its way in a narrow channel between the circumference of the fan and some low cliffs opposite. It looks as though at no very distant date the main stream from Chushal will be blocked by the fan of this tributary and a lake formed 25 miles long, extending back to the Tsaka La. In the exit valley of the Pangong Lake there are at the present time two small lakes and several marshy flats formed by the partial choking of the main valley by deposits accumulated by tributaries.

With deference and without either wishing or being able to traverse Ellsworth Huntington's theory of the formation of the lake, I advance my opinion for what it is worth, that the blocking of the exit stream by the fan of its tributary, though perhaps unlikely, was not impossible.

(6) *Orarucha Tso.* Longitude 78° 30′, latitude 34° 15′, near junction of Changchenmo and Shayok rivers.

The main lake is about ¾ of a mile long by 300 yards wide. Two smaller lakes lie in continuation of the main lake to a distance of about ¼ of a mile further down the valley. At the bottom of the lowest one the dam becomes apparent. It is moraine stuff consisting of large blocks of granite brought down from the glacier.

crowned hill on the west of the valley. The lakes were originally one, a subsequent transport of rocks by a small glacier on the west having divided the two smaller lakes, and a fan, the main lake from the other two. Water, however, flows from one to the other in each case. There is, as well as I could judge, no percolation through the dam.

The water is fresh and its colour is dark green. The elevation of this lake is not more than 1,000 feet below the Togar Pass, the height of which cannot, I think, be below 18,000 feet.

(7) *Tsultak.* Longitude 78°, latitude 34° 5′.

A bow-shaped lake on the east side of the Chong La. Greatest length about 350 yards and greatest breadth about 100 yards; colour of water is deep green. The lake has been formed by the meeting of two moraines from opposite sides of the valley. The overflow now drains out between the two moraines. Greatest depth 17 feet.

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RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

Part 3.] 1911. [September

THE MINERAL PRODUCTION OF INDIA DURING 1911. BY H. H. HAYDEN, C.I.E., F.G.S., *Director, Geological Survey of India.*

CONTENTS.

I.—INTRODUCTION.

THE method of classification adopted in the first Review of Mineral Production published in these *Records* (Vol. XXXII), although admittedly not entirely satisfactory, is still the best that can be devised under present circumstances. The methods of collecting the returns are becoming more precise every year and the

machinery employed for the purpose more efficient. Hence the number of minerals included in Class I—for which approximately trustworthy annual returns are available—is gradually increasing, and it is hoped that before long the minerals of Class II—for which regularly recurring and full particulars cannot be procured—will be reduced to a very small number. In the case of minerals, such as tin-ore, still exploited chiefly under primitive native methods and thus forming the basis of an industry carried on by a large number of persons each working independently and on a very small scale, the collection of reliable statistics is impossible, but the total error from year to year is not improbably approximately constant and the figures obtained may be acepted as a fairly reliable index to the general trend of the industry. In the case of gold, the small native alluvial industry contributes such an insignificant portion to the total outturn that any error from this source may be regarded as negligible.

Total value of production.

The annexed table (Table 1) shows the values of the chief minerals produced in 1911 as compared with the values for 1910. In the year 1909 there was a fall, for the first time since 1898, in the total value. This fall, which amounted to 4·6 per cent, was, however, converted into a small rise in 1910, which, however, has again given place to an insignificant fall of about ½ per cent in the year under review. The fall was due, in the last instance, to the greatly reduced production of manganese-ore and salt. At the same time, jade, graphite and saltpetre also show reduced production.

TABLE 1.—*Total value of Minerals for which Returns of Production are available for the years 1910 and 1911.*

—	1910.	1911.	Increase.	Decrease.	Variation per cent.
	£	£	£	£	
Coal	2,455,544	2,502,616	47,072	..	+ 1·9
Gold	2,202,486	2,238,143	35,657	..	+ 1·62
Petroleum	835,927	884,398	48,471	..	+ 5·8
Manganese-ore (*a*)	849,455	648,701	..	200,754	— 23·6
Salt (*b*)	565,078	469,235	..	95,843	— 17

(*a*) Value f. o. b. at Indian ports. (*b*) Prices without duty.

TABLE 1.—*Total value of Minerals for which Returns of Production are available for the years 1910 and 1911*—contd.

——	1910.	1911.	Increase.	Decrease.	Variation per cent.
	£	£	£	£	
Saltpetre . . .	223,762	220,012	..	3,750	— 1·7
Mica (*a*) . . .	177,152	188,642	11,490	..	+ 6·5
Lead-ore and lead .	163,022	181,989	18,967	..	11·6
Tungsten-ore . .	38,873	99,989	61,116	..	+ 157
Ruby, sapphire and spinel.	58,849	67,594	8,745	..	15
Iron-ore (*b*) . .	9,811	44,487	34,676	..	453·4
Jadestone . . .	64,747	41,660	..	23,087	— 35·7
Tin-ore and tin . .	18,578	24,931	6,353	..	34·2
Silver. . . .	4,968	11,575	6,607	..	133
Graphite . . .	20,479	9,425	..	11,054	— 54
Chromite . . .	2,315	5,072	2,757	..	+ 119
Alum . . .	2,869	2,792	..	77	— 2·7
Garnet . . .	1,842	1,845	3	..	..
Corundum . . .	323	1,660	1,337	..	+ 414
Magnesite . . .	1,382	1,047	..	335	— 24·2
Diamond . . .	590	478	..	112	— 19
Amber . . .	283	133	..	150	— 53
Miscellaneous . .	604	837	233	..	+ 38·6
Total .	**7,698,939**	**7,657,261**	293,484	335,162	**·54**
			£41,678		

(*a*) Export values.
(*b*) For provinces other than Bengal, values estimated approximately.

A considerable number of minerals, however, show a steady rise, the chief of these being coal, gold, petroleum and wolfram. The state of the industry in the first three may be safely regarded as an indication of prosperity in the mineral industry generally, and the fall in the total value for 1911 must be attributed, not to any general industrial depression, but to the exaggerated effects of the curtailment of output of a single mineral, *viz.*, manganese. The minerals showing the most marked increase in value of production are iron, wolfram, lead, tin, silver, chromite and rubies, the increase varying from 10 to over 450 per cent.

Mineral concessions granted.

There was a considerable increase in the number of mineral concessions granted during the year, 775 having been granted as against 635 in the previous year. The increase is due chiefly to the large number of licenses and leases taken out in Burma, 306 prospecting licenses having been granted as against 156 in the year 1910. This is due to the rush for wolfram in the Tenasserim province of Lower Burma. In the Central Provinces, also, a large number of new licenses were taken out, although not quite so many as in the preceding year. Most of the licenses and leases taken out in that province were for manganese. The number of concessions granted in other parts of India was comparatively insignificant, amounting only to a little over 12½ per cent of the total, the remainder being divided between Burma and the Central Provinces in the ratio of about 53 : 35 per cent. By far the greater proportion of the concessions granted, *viz.*, over 76 per cent represents prospecting licenses, and it is a notable fact that, although the outturn of wolfram in Mergui and Tavoy during the year was over 1,300 tons, not a single mining lease for this mineral had been granted in either of those districts up to the end of 1911.

II.—MINERALS OF GROUP I.

Chromite.	Graphite.	Magnesite.	Ruby, Sapphire and Spinel.
Coal.	Iron-ore.	Manganese-ore.	Salt.
Diamonds.	Jadeite.	Mica.	Saltpetre.
Gold.	Lead-ore.	Petroleum	Tin-ore.
			Tungsten-ore.

Chromite.

There has been a marked improvement in the output of chromite from Baluchistan during the year under review. In 1907 the industry reached its highest point, and in the following year there was a rapid decline of nearly 50 per cent. in the outturn. There was a small but only temporary recovery in 1909, and in 1910 there was a very rapid fall of 81 per cent., due not only to the complete extinction of the industry in Mysore, but to its decline also in Baluchistan. In 1911 there was still no output from Mysore, but that of Baluchistan rose by 119 per cent in quantity.

TABLE 2.—*Quantity and Value of Chromite produced in India during 1910 and 1911.*

Province.	1910.		1911.	
	Quantity.	Value.	Quantity.	Value.
	Tons.	£	Tons.	£
Baluchistan	1,737	2,315	3,804	5,072
Mysore	*Nil*	..	..	..
Total .	1,737	2,315	3,804	5,072

Coal.

Total production.

The small improvement in the output of coal noted in last year's Report has been well maintained during the period under review, the output having risen from 12,047,413 tons in 1910 to 12,715,534 tons last year—a figure very much higher than that reached in any year except 1908. Concurrently with the increased output there has been a general fall in pit's mouth value in most of the provinces. The only exceptions to this are: Assam, where pit's mouth value rose by one pie per ton; Central India, where the rise was nearly six annas; Baluchistan and the Central Provinces. In Bengal the pit's mouth value fell to Rs. 2-11-4 per ton.

TABLE 3.—*Origin of Indian Coal raised during 1910 and 1911.*

——	Average of last five years.	1910.	1911.
	Tons.	Tons.	Tons.
From Gondwana coal-fields . . .	11,108,197	11,635,540	12,329,458
From Tertiary coal-fields . .	415,343	411,873	386,076
Total .	..	12,047,413	12,715,534

TABLE 4.—*Average price (per ton) of Coal extracted from the mines in each Province during the year 1911.*

Province.	Average price per ton.		
	RS.	A.	P.
Assam	4	12	1
Bengal	2	11	4
Rajputana (Bikanir)	3	2	11
Central India	3	2	11
Punjab	5	1	1
Baluchistan	10	11	1
Central Provinces	4	0	3
Nizam's Territory	6	0	0
Others	5	0	0

Consumption and export

In spite of the increased outturn, there was a distinct fall, amounting to 14 per cent in the quantity of coal exported, the amount consumed in India being nearly 8,000 tons more than last year, of which increase the Railways were responsible for a little over 53 per cent, the total amount of Indian coal used by them having been 4,223,020 tons. The actual reduction in exports of coal was 125,766 tons, of which Australia was responsible for the greater part, that colony having taken over 89,000 tons in 1910 and not quite 8,000 tons in 1911.

TABLE 5.—*Exports of Indian Coal.*

—	1910.	1911.
	Tons.	Tons.
Aden	7,383	11,667
Ceylon	521,596	493,511
Straits Settlements	235,885	224,794
Sumatra	100,211	109,319
Other Countries	121,479	21,497
Total	**986,554**	**860,788**
Coke	1,812	1,389
Total of Coal and Coke	**988,366**	**862,177**

Imports.

There was a slight rise in imports, which amounted, including Government stores (patent fuel and coke), to 340,106 tons. Of this increase Australia claims nearly 8,000 tons, but the imports from that colony still amounted only to 35·7 thousand as against 54·8 thousand in 1909.

TABLE 6.—*Imports of Coal, Coke and Patent Fuel during 1910 and 1911.*

——	1910.	1911.
	Tons.	Tons.
From Australia (including New Zealand)	28,040	35,703
" Natal	18,224	15,086
" United Kingdom	244,215	232,865
" Other countries	8,480	22,356
Total	**298,959**	**306,010**
Coke	7,977	7,661
Patent fuel	9,060	4,998
Government stores	16,625	21,437
Total	**332,621**	**340,106**

Provincial production.

Practically the whole increase in production during 1911 is attributable to the Bengal fields, which increased their outturn by nearly 700.000 tons. At the same time the Central Indian output increased by 13,000 tons and that of the Palana Colliery in Bikanir by 2,000 tons. All the other fields show a decrease in production, the most marked being those of the Punjab, the outturn of which declined by over 18,000 tons, representing a fall of almost 38 per cent. This was due to the final abandonment by the North-Western Railway Company of their Dandot Colliery in June of last year and to the employment by them of Bengal instead of Punjab coal for locomotive purposes. The colliery, however, has not been closed down, but is being worked with some vigour by Messrs. Thakur Das, Ramji Das, who find a ready sale for their coal to brick and lime-burners.

TABLE 7.—*Provincial Production of Coal during the years 1910 and 1911.*

Province.	1910.	1911.	Increase.	Decrease.
	Tons.	Tons.	Tons.	Tons.
Baluchistan	52,614	45,707	..	6,907
Bengal	10,778,530	11,468,904	690,374	..
Central India . . .	130,400	143,558	13,158	.
Central Provinces . .	220,437	211,616	..	8,821
Eastern Bengal and Assam .	297,236	294,893	..	2,343
Hyderabad] . . .	506,173	505,380	..	793
North-West Frontier Province	90	140	50	..
Punjab	49,189	30,575	..	18,614
Rajputana (Bikanir) . .	12,744	14,761	2,017	..
Total .	12,047,413	12,715,534	*705,599*	*37,478*

Gondwana fields.

The Gondwana fields claim almost 97 per cent of the total output for the year. These fields have increased their output by a little under 6 per cent over the figures for 1910. Most of this increase is due to the Jherria field, the production of which rose by nearly 600,000 tons, whilst that of the Raniganj field increased by nearly 100,000 tons. The Jherria field is now responsible for more than half of the Indian output of coal, whilst Jherria and Raniganj together are accountable for over 80 per cent of the total output. In 1910 mining was begun in the Hingir-Rampur (Sambalpur) field, but only 830 tons were produced. The outturn, however, has now risen to over 5,000 tons. Of the other Gondwana fields Pench Valley, Daltonganj and Ramgarh-Bokaro show decreased outturns. The last-named field, however, like that of Hingir-Rampur, is in an early stage of exploitation, and the variation of a few hundred tons in its small outturn has no significance. Increases took place in the outputs of the Giridih, Umaria, Mohpani and Bellarpur fields, whilst the outturn of Singareni was practically unchanged.

TABLE 8.—*Output of Gondwana Coal-fields for the years 1910 and 1911.*

Coal-fields.	1910. Tons.	1910. Per cent. of Indian Total.	1911. Tons.	1911. Per cent. of Indian Total.
Bengal—				
Daltonganj . . .	84,996	·70	70,662	·55
Giridih	679,304	5·64	704,443	5·54
Jherria	5,794,616	48·10	6,373,728	50·13
Rajmahal . . .	2,788	·05	1,978	·02
Ramgarh-Bokaro . .	3,390		468	
Raniganj . . .	4,212,606	34·98	4,311,956	33·95
Sambalpur (Hingir-Rampur).	830		5,669	
Central India—				
Umaria . . .	130,400	1·08	143,558	1·13
Central Provinces—				
Bellarpur . . .	93,276	·77	96,603	·76
Pench Valley . . .	87,677	·73	63,030	·50
Mohpani . . .	39,484	·33	51,983	·41
Hyderabad—				
Singareni . . .	506,173	4·20	505,380	3·97
Total .	**11,635,540**	**96·58**	**12,329,458**	**96·96**

Tertiary fields.

With the single exception of the Palana Colliery in Bikanir, the output of which rose by about 15 per cent, from 12,744 tons to 14,761 tons, all the Tertiary fields show decreased outputs during the year under review. As already pointed out, the most marked fall took place in the Punjab, where the output of the fields in the Jhelum district, that is to say, chiefly the Dandot Colliery, fell from over 46,000

tons to a little under 27,000. There was also an insignificant decrease in the outturn of the Margherita Collieries in Assam and of the Khost Colliery in Baluchistan, whilst the superficial and sporadic workings in the Sor Range of the latter province reduced their output by about 66 per cent, their total production being a little over 3,000 tons.

TABLE 9.—*Output of Tertiary Coal-fields for the years 1910 and 1911.*

Coal-fields.	1910.		1911.	
	Tons.	Per cent of Indian Total.	Tons.	Per cent of Indian Total.
Baluchistan—				
Khost	43,428	·36	42,410	·33
Sor Range, Mach, etc. .	9,186	·08	3,297	·03
Eastern Bengal and Assam—				
Makum . . .	297,236	2·47	294,893	2·32
North-West Frontier Province—				
Hazara	90	·41	140	·24
Punjab (Salt Range)—				
Jhelum District . .	46,655		26,982	
Mianwali . . .	1,884		2,522	
Shahpur . . .	650		1,071	
Rajputana—				
Bikanir . . .	12,744	·10	14,761	·12
Total .	411,873	3·42	386,076	3·04

Labour.

In spite of the large increase in production of coal over the previous year, there was practically no change in the amount of labour employed, the increase in the number of persons employed daily being only 74. This means a still further increase in efficiency ; and whereas in

the year 1910 the amount of coal raised per person employed, was 103·7 tons as against 99·3 in the previous year, the figure for the year under review is 109·47 tons for the whole of India, whilst for the Bengal fields it is 114·7. There is thus a very marked and steady increase of efficiency. The increase, however, is attributable chiefly to Bengal, although in Central India there has been a marked rise in output per person employed from 93·3 tons in 1910 to 100·4 in the year under review. Singareni also shows increased efficiency, the corresponding figures being 64·29 in 1911 as against 56·05 in 1910. In the Bengal fields the output per person employed below ground has risen from 171·9 tons in 1910 to 177·6 in the year under review. The corresponding figure for 1908 was only 153·5 tons, and there has thus, in the course of 4 years, been an increase of outturn per person employed of 24 tons. This furnishes a very striking evidence of the increase of efficiency in the methods employed in Bengal.

TABLE 10.—*Average number of persons employed daily in the Indian Coalfields during 1910 and 1911.*

—	Number of persons employed daily.		Output per person employed.	Number of deaths by accidents.	Death-rate per 1,000 persons employed.
	1910.	1911.	1911.	1911.	1911.
			Tons.		
Baluchistan . .	1,073	932	49·04	7	7·51
Bengal . . .	98,281	99,983	114·70	118	1·18
Central India . .	1,398	1,430	100·39	2	1·39
Central Provinces .	2,419	2,292	92·32	4	1·74
Eastern Bengal and Assam.	1,925	1,965	150·07	13	6·61
Hyderabad . .	9,031	7,860	64·29	23	2·92
North-West Frontier Province.	5	5	28	..	..
Punjab . .	1,782	1,505	20·31	6	3·98
Rajputana . . .	167	183	80·66	2	..
Total .	**116,081**	**116,155**	..	**175**	..
Average . . .	..	..	*109·47*	..	*1·5*

Diamonds.

Diamonds, again, show a decline in output, amounting to nearly 32 per cent in quantity and 19 per cent in value. This is due to a further decline in the outturn from Madras, which has fallen from over 111 carats in 1909 to a little under 9 in the year under review.

TABLE 11.—*Quantity and Value of Diamonds produced in India during 1910 and 1911.*

	1910.		1911.	
	Quantity.	Value.	Quantity.	Value.
	Carats.	£	Carats.	£
Central India . . .	62·24	577	44·21	475
Madras	15·5	13	8·75	3
Total .	77·74	*590*	52·96	*478*

Gold.

The output of gold increased by 10,447 ounces representing a rise of 1·62 per cent on the output of the previous year. Most of this increase is due to the Mysore fields, the output of which improved by over 7,000 ozs. At the same time the new Anantapur field in Madras more than doubled its output, having produced over 5,000 ozs. as against 2,500 ozs. in the previous year. The production shown against Myitkyina represents chiefly the gold won by the dredging operations being carried on by the Burma Dredging Company. It also includes nearly 38 oz. of platinum, which metal, although previously known to occur in Burma, had not hitherto been found in any appreciable quantity.

TABLE 12.—*Quantity and Value of Gold produced in India during 1910 and 1911.*

	1910.		1911.		Average number of persons employed daily.
	Quantity.	Value.	Quantity.	Value.	
	Ounces.	£	Ounces.	£	
Bombay—					
Dharwar	737	2,590	2,993	10,449	264
Burma—					
Myitkyina	5,972·24	22,930	6,390·38	24.269	178 (*a*)
Katha and Pakokku	24·71	119	22·28	110	4 (*b*)
Hyderabad	15,762·24	59,394	13,726·4	52,070	1,340
Mysore	547,746	2,105,944	555,011	2,129,873	Not reported.
Madras	2,532	10,120	5,284	20,835	1,110
Punjab	106	432	134·62	518	245
United Provinces	3·75	13	5 5	19	20
Total	**572,883·94**	*2,201,542*	**583,567·18**	*2,238,143*	**3,161**

(*a*) Inclusive of the figures for platinum.
(*b*) Exclusive of the figures for Katha which are not available.

Graphite.

There was a slight rise in the output of graphite during the year, *viz.*, from 3,992 tons in 1910 to a little over 4,047·5 last year. Almost the whole of this came from Travancore, only 54 tons having been obtained in Vizagapatam. In spite of the increase of the output, however, the value of the graphite produced fell from £20,479 to £9,425. This, however, cannot be regarded as any particular indication of the prosperity or otherwise of the industry, the whole of which is practically a monopoly under the Travancore State. Prices obtained, therefore, depend on exceptional factors. The value of the outturn for the year under review has been returned at between £2 and £3 per ton—a figure, which, in view of the ordinary market rates as well as the quality of the Travancore mineral, would appear to be a good deal too low,

Iron-ore.

The effect of the operations of the Tata Iron and Steel Company has now begun to show, and the total output of iron-ore during the year under review, leapt up from 54,626 tons in 1910 to 366,180 tons, that is to say, 453·4 per cent. Of this increase a certain proportion was also due to the iron-ore won in Singhbhum by the Bengal Iron and Steel Company. Also an appreciable share is to be attributed to Burma, where the output increased from between 7,000 and 8,000 tons to nearly 21,000. In the returns for the present and future years iron-ore will no doubt take a still more prominent position.

TABLE 13.—*Production of Iron-ore during the years 1910 and 1911.*

	1910.		1911.	
	Production.	Value.	Production.	Value.
	Tons.	£	Tons.	£
Bengal—				
Burdwan	24,387	3,655	5,456	780
Manbhum	..	..	..	..
Orissa	..	..	300,000	40,000(*a*)
Singhbhum	17,646	2,703	36,276	7,162
Other districts	620	260	610	237
Bombay	1	..	1	..
Burma	7,480	1,995	20,995	5,599
Central India	268	72	585	156
Central Provinces	3,637	970	1,944	470
Hyderabad	485	129	223	59
Madras	..	..	..	..
Rajputana	64	17	68	18
United Provinces	38	10	22	6
Total	**54,626**	*9,811*	**366,180**	*54,487*

(*a*) Figures kindly furnished by Tata Iron and Steel Company.

Jadeite.

It has been pointed out in the previous Reviews that the returns of production of jadeite are of no value in estimating the state of the industry, since the declared output is valued at a figure which is only a small fraction of the value of the amount exported. Thus, in the year 1911, the exports were valued at £41,660, whereas the output is said to have been only 2,063 cwt., valued at £11,493. The total amount exported was only a little higher than the declared production, being 2,113 cwt., the export value being thus between £19 and £20 per cwt. and the pit's mouth value between £5 and £6 per cwt. Both pit's mouth and export values during the year under review were considerably lower than the corresponding values for the previous year, the latter having stood at £23 for export and £6-15-0 for spot values.

Lead-ore.

There was a further increase in the quantity of lead-ore turned out in Burma during the year 1911, the value of production of lead having risen from £163,000 to nearly £183,000, whilst the value of the silver produced was almost trebled. Practically the whole output was derived from the mines at Bawdwin, where the silver-lead slags are still being worked, but are also being supplemented by a certain amount of ore. Outside Burma only 2½ tons of lead-ore were obtained, *viz.*, in Drug in the Central Provinces and in Karnul in Madras.

TABLE 14.—*Production of Silver-lead ore in Burma during 1910 and 1911.*

	1910.			1911.		
	Quantity.	Value		Quantity.	Value.	
	Lead-ore and slag.	Lead-ore and lead	Silver.	Lead-ore and slag.	Lead-ore and lead.	Silver.
	Tons.	£	£	Tons.	£	£
Mandalay . .	23	Not known		..	..	..
Toungoo . .	500	1,000	..	140	587	..
Northern Shan States.	(Ore) 975	2,461	538	(Ore) 3,218	2,169	2,642
	(Slag) 29533	159,081 (*a*)	4,430 (*b*)	(Slag) 31,954	179,102 (*c*)	8,933 (*d*)
Southern Shan States.	180	480	..	49	131	..
Total .	31,211	*163,022*	*4,968*	35,361	*181,989*	*11,575*

(*a*) Value of 12,404 tons of lead extracted.
(*b*) Value of 44,300 ounces of silver extracted.
(*c*) Value of 12,793 tons of lead extracted.
(*d*) Value of 80,145 oz. of silver extracted.

Magnesite.

There was a slight fall in the outturn of magnesite during the year, the total output being 3,490 tons as against 5,182 tons in the previous year. Corresponding with this, there was a fall in value from £1,382 to £1,047.

Manganese-ore.

This group of minerals shows the most serious falling off of any during the year under review, the production having fallen by over 16 per cent in quantity and 23½ per cent in value. It has already been pointed out in previous reviews that the least unsatisfactory method of determining the value of the manganese-ore industry of India is by representing the annual production in terms of the value of the ore f. o. b. at Indian ports. Owing, therefore, to the fluctuations in the price of ore, the value of the outturn in any one year, as shown in this review, may be considerably higher or considerably lower than a similar outturn in another year. As no manganese-ore has hitherto been consumed in India, the whole output has been produced for purposes of export. According, therefore, to the fluctuations in the market, the amount exported may or may not cover the whole amount produced. When prices are low, the export of poor ores having a long lead to the nearest sea-port becomes unprofitable. Stocks consequently accumulate, and although the actual outturn from the mine during any given year may have been considerable, the state of the industry may nevertheless at the same time have been depressed. The figures given in table 15 should, therefore, be considered in conjunction with the export figures for the corresponding period. These amounted to 553,628 tons as against 586,577 tons in the year 1910. Thus the total quantity exported amounted only to a little less than 86 per cent. of the quantity produced. This decline in the industry is due to the fall in the price of ore during the year. During 1910, the average prices of first and second-grade ores were 9·5*d.* and 9·3*d.* respectively, whereas the corresponding prices for the year 1911 were 9·3*d.* and 9*d.*, and this fall in value has led to a curtailment not only of exports, but also of output.

TABLE 15.—*Output of Manganese-ore for the years 1910 and 1911.*

	1910.		1911.	
	Quantity.	Value f. o. b. at Indian ports.	Quantity.	Value f. o. b. at Indian ports.
Bengal—	Tons.	£	Tons.	£
Gangpur State .	41,958	41,259	25,152	25,257
Bombay—				
Panch Mahals . .	30,396	31,789	45,330	45,519
Ratnagiri . . .	525	424	..	..
Central India—				
Jhabua	12,664	11,239	7,319	6,068
Central Provinces—				
Balaghat . . .	161,987	182,235	144,642	147,053
Bhandara . . .	159,164	179,059	119,606	121,600
Chhindwara . . .	19,556	22,000	1,540	1,566
Jubbulpore . . .	300	197	..	..
Nagpur . . .	211,232	237,636	179,263	182,500
Madras—				
Bellary	500	425	..	..
Sandur	73,666	62,616	66,950	53,002
Vizagapatam . . .	46,441	39,475	58,915	46,641
Mysore	42,518	41,101	21,573	19,595
Total .	**800,907**	*849,155*	**670,290**	*648,701*

Mica.

There has been an appreciable increase, amounting to nearly 50 per cent in the outturn of mica, 33,896 cwt. being returned in the year under review as against 22,700 cwt. in the previous

year. As pointed out in previous reviews, however, the output figures are undoubtedly incomplete, since in almost every year the figures for export are considerably higher than those given for outturn in the district returns. During the past year, 46,335 cwt. were exported against 39,612 cwt. in 1910, the output as returned for the year, amounting to only 73 per cent of the quantity exported. The average number of labourers employed daily in the industry during the year 1911 was 16,404, an increase of over 16 per cent.

TABLE 16.—*Production of Mica in 1910 and 1911.*

——	1910	1911
	Cwt.	Cwt.
Bengal	18,356·5	25,225
Madras	3,586	7,462
Mysore	..	18
Rajputana	757	1,191
Total	**22,699·5**	**33,896**

Petroleum.

Production.

The figures for output of crude petroleum during the past year are in every way satisfactory and show a marked increase on those for the year 1910. They are, however, still behind those for 1909, in which year the output of petroleum reached the highest figure that has hitherto been attained, *viz.*, 233,678,087 gallons. In the year 1910 the production fell by 8 per cent but has now risen again by 5 per cent to 225,792,094 gallons, which is only some 8,000,000 gallons below the output for 1909. This rise was due chiefly to the increased output of the Singu field, which rose by 60 per cent from 31,500,000 gallons to 50,500,000. At the same time, there was a small decline of 8,500,000 gallons or a little under 1½ per cent in the outturn of the Yenangyaung field. It is probable, however, that the check which took place in the rate

of production in that field in 1910 will have been only temporary and that the output from the deeper sands now being exploited will add largely to the production of the field. The new Minbu field has not yet produced any appreciable quantity of oil, although its production rose from 18,320 gallons in 1910 to 632,458 gallons in the year under review. There was also a small increase, amounting to nearly 250,000 gallons, in the output of the Digboi field in Assam.

TABLE 17.—*Production of Petroleum during 1910 and 1911.*

—	1910	1911
	Gallons.	Gallons.
Burma—		
Akyab	22,258	19,630
Kyaukphyu	33,544	36,970
Magwe (Yenangyaung)	174,967,298	166,494,319
Myingyan (Singu)	31,524,175	50,564,765
Pakokku (Yenangyat)	4,942,308	4,476,074
Minbu	18,320	632,458
Thayetmyo	*Nil*	1,315
Eastern Bengal and Assam—		
Digboi	3,320,680	3,565,163
Punjab	1,064	1,400
Total .	**214,829,647**	**225,792,094**

Exports. There was a still further increase in the export of paraffin wax, which rose from 23,718 cwt. in 1910 to 24,679 cwt., valued at £366,337, in 1911.

Imports. Owing to the rate war and consequent fall in prices prevailing throughout the greater part of the year, the imports of foreign kerosene rose by over 30 per cent and amounted to over 75,000,000 gallons.

TABLE 18.—*Imports of Kerosene Oil during 1910 and 1911.*

—	1910.	1911.
	Gallons.	Gallons
Bornea	5,410,039	11,400,224
Roumania	..	..
Russia	1,196,700	6,518,968
Straits Settlements	5,882,961	679,307
Sumatra	5,730,580	1,009,070
United States of America	39,117,664	55,602,821
Other Countries	21,961	9,004
Total .	**57,359,905**	**75,219,394**

Labour.

The average daily number of labourers working in the various fields during the year 1911 was 6,585.

Ruby, Sapphire, and Spinel.

The output of the Burma ruby mines shows a satisfactory increase from 262,019 carats in 1910 to 288,213 carats, valued at £67,594 during the year under review. This represents an increase of 10 per cent in quantity and nearly 15 per cent in value. The average number of persons employed daily in the industry was 1,505.

Salt.

There was a marked decline, amounting to over 14 per cent, in the production of salt other than rock-salt during the year under review, the outturn having fallen from 1·55 million to 1·32 million tons. On the other hand, there was a small increase, amounting to 5,549 tons or 4 per cent, in the production of rock-salt. At the same time, there was a very considerable increase in the amount of foreign salt imported. This rose from 496,165 tons in 1910 to 559,065 tons in 1911, representing an increase of nearly 13 per cent.

TABLE. 19.—*Provincial Production of Salt for the years 1910 and 1911.*

PROVINCE.	1910.	1911.
	Tons.	Tons.
Aden	67,347	100,392
Bengal	22	28
Bombay and Sind	483,322	468,328
Burma	22,692	26,235
Gwalior State	52	37
Madras	464,607	414,521
Northern India	514,917	316,341
Kashmir	16	..
Total .	1 552,975	1,325,882

TABLE 20.—*Production of Rock-salt during 1910 and 1911.*

Mines.	1910.	1911.
	Tons.	Tons.
Salt Range	119,868	124,605
Kohat	17,098	17,585
Mandi State	3,671	3,996
Total .	140,637	146,186

Saltpetre.

Production.

In the year 1910 it was attempted for the first time to collect from the various provinces statistics of the outturn of saltpetre. Table 21 shows the figures thus obtained for the years 1910 and 1911. From this it will be seen that the production has fallen slightly, the decline, however, being not quite 2 per cent.

Exports.

The total amount exported was 14,851 tons or 177 tons more than the total production. In the previous year, however, the output was nearly 500 tons in excess of the amount exported. Table 22 shows the countries to which the exports were made.

TABLE 21.—*Production of Saltpetre during 1910 and 1911.*

—	1910.		1911.	
	Quantity.	Value.	Quantity.	Value.
	Tons	£	Tons	£
North-West Frontier Province	22	481	12	..
Punjab	3,481	55,034	2,845	51,589
United Provinces of Agra and Oudh.	5,225	72,987	5,616	91,658
Behar	6,772	92,099	5,818	73,847
Central India	23	176	23	166
Rajputana	363	2,985	360	2,752
Total .	**15,886**	*223,762*	**14,674**	*220,012*

TABLE 22.—*Distribution of Saltpetre exported during 1910 and 1911.*

—	1910.		1911.	
	Quantity.	Value.	Quantity.	Value.
	Cwt.	£	Cwt.	£
China	88,300	73,433	85,602	70,979
France	3,325	2,543	2,095	1,715
United Kingdom . . .	57,105	43,162	52,130	42,744
United States of America .	79,879	58,222	72,542	55,381
Other Countries . . .	79,353	53,255	84,648	59,990
Total .	**307,962**	*230,615*	**297,017**	*230,809*

Tin-ore.

The figures for the production of tin-ore must still be regarded as somewhat unreliable. In the previous review the reasons for this have been pointed out.

Production.

There was a considerable rise in the total production during the year under review, the outturn of block tin from Mergui having risen from 1,507 cwt. to 1,764 cwt. valued at £15,543. On the other hand, the output of tin-ore from Mergui fell to 1,141 cwt. This, however, was compensated for by the production from the Southern Shan States, the Southern Shan States Syndicate having now brought the Mawchi mine into working. The outturn from this area is stated to be 802 cwt., but this includes a certain amount of wolfram. From table 23 it will be seen that the increase in the value of the output of tin and tin-ore during the year was £6,353, an increase of over 34 per cent on the previous year. It is probable that a very considerable increase will be noticed also in the next review, since attention is now being turned to the great possibilities of both Mergui and Tavoy as tin-producing districts and scientific methods of work are being introduced. The pioneers in this movement, Messrs. J. R. and H. W. Booth, of the Hindu Chaung Mining and Dredging Co., have already set up a suction dredge on the Hindu Chaung at about 40 miles to the east of Tavoy town. The results of their prospecting are said to be promising. The erection of this dredge represents the first attempt to replace primitive methods by modern scientific machinery, and the enterprise and energy displayed by Messrs. Booth will, it is to be hoped, meet with the full measure of success that they so thoroughly deserve. It is probable that before long their example will be followed both in the Mergui Archipelago and in other parts of Tavoy.

TABLE 23.—*Production of Tin-ore and Tin for the years 1910 and 1911.*

	1910.				1911.			
	BLOCK TIN.		TIN-ORE.		BLOCK TIN.		TIN-ORE.	
	Quantity.	Value	Quantity.	Value	Quantity.	Value	Quantity.	Value.
	Cwt.	£	Cwt.	£	Cwt.	£	Cwt.	£
Bengal—								
Hazaribagh	..	..	3	26	..	..	3	27
Burma—								
Mergui	1,507	10,935	1,767½	7,589	1,764	15,543	1,141	6,101
Southern Shan States	..	..	..	..	..	..	802 (*a*)	3,260 (*a*)
Tavoy	..	..	6	28	..	..	..	..
Total	**1,507**	*10,935*	**1,776½**	*7,643*	**1,764**	*15,543*	**1,946**	*9,388*

(*a*) Includes figures for wolfram.

Imports.

The imports of block tin in 1911 amounted to 35,001 cwt. as against 38,687 cwt. in the previous year. Almost the whole of this came from the Straits Settlements.

Tungsten-ore.

Wolfram.

There has been very marked activity during the past year in the wolfram industry in Tavoy and also to some extent in Mergui, some 66 prospecting and exploring licenses having been taken out in these two districts with a view to searching for wolfram, tin and associated minerals. There has consequently been a very considerable increase in the wolfram output, which rose from 395 tons in 1910 to 1,308 tons, valued at £99,989, in the year under review. Work is being carried on at a large number of localities, chiefly in the mountains to the east and north-east of Tavoy, where wolfram occurs in fissure veins traversing the granite and associated argillaceous rocks metamorphosed by it. In addition to a number of Chinese and Burmese, working mostly on a comparatively small scale, certain European companies, such as the Rangoon Mining Company, the Tavoy Concessions, the Burma-Malaya, etc., are engaged in opening up some of the larger deposits. Hitherto there has been rather a tendency to a short-sighted policy in the methods of development employed generally in Tavoy, more attention having been paid to the immediate gain to be had from a large present outturn than to the ultimate benefit to be derived from a thorough knowledge of the extent and relationships of the ore-bodies. Although not a single mining lease had been granted up to the end of the year 1911, extensive mining operations were nevertheless carried on on certain properties. It is to be hoped, however, that the industry will soon settle down to more normal conditions, and that those engaged in it will realise that their financial interests will be best served by systematic development and that the methods at present being employed, and which result merely in picking the eyes out of the country, can only be injurious in the end.

A certain amount of wolfram was also won at Mawchi in the Southern Shan States, but no detailed returns are available, the figures for wolfram having been included in those for tin, since the concentrates of the two metals are not separated locally.

III.—MINERALS OF GROUP II.

Alum.

The condition of the alum industry of Mianwali district in the Punjab was practically unchanged, the output being 6,160 cwt., valued at £2,792, as against 6,220 cwt. in the previous year.

Amber.

There was a considerable fall in the output of amber, which dropped from 63 cwt., valued at £283, in the year 1910 to 14 cwt., valued at £133, in the year under review.

Bauxite.

Twelve tons of bauxite, valued at £5, were produced in the Jubbulpore district of the Central Provinces. This no doubt was merely a sample, but it is probable that before long an attempt will be made to develop what gives promise of being a prosperous industry.

Borax.

A small quantity (17 cwt.) of borax, valued at £1, was produced in Kashmir in the year under review, but the sulphur and borax trade of Puga in Ladak appears to have died out completely, the whole of the borax exported from India being derived from Tibet. The amount exported during the year 1911 was only 3,241 cwt., valued at £3,398, a fall of nearly 50 per cent. on the exports of the previous year.

Building materials.

As pointed out in the previous review, the returns obtainable for building materials and road-metal are too incomplete to be of any real value. They are, however, interesting as representing an important item in the mineral industries of the country. The outputs of the respective provinces are shown in table 24. The total value amounts to £246,446 as against £222,400 in the previous year.

Clay.

Like those for building materials, returns for clay are extremely incomplete. In Burma the output was 710,705 tons and in Madras 418,304 tons. Returns from the other provinces are insignificant, although no doubt the amounts produced are very little inferior to those of Burma and Madras. The total quantity for the year 1911 is returned as 1,168,858 tons, valued at £66,207.

TABLE 24.—*Production of Building materials and Road metal in India during 1911.*

	NATURE OF MATERIALS.																	
	GRANITE.		LATERITE.		LIME		LIMESTONE AND KANKAR.		MARBLE.		SANDSTONE.		SLATE.		TRAP.		MISCELLANEOUS.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity	Value.	Quantity.	Value.
	Tons.	£	Tons.	£	Tons	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£
Baluchistan	..	..	..	..	..	..	252	320	..	..	..	..	..	..	..	..	..	..
Bengal .	2,708	395	17 493	2,187	266	121	27,122	6,196	..	..	46,955	8,498	1,014	1,567	623,543	1,484	546,802	14,276
Bombay .	..	..	..	..	..	..	400	133	..	..	..	..	..	..	..	..	..	..
Burma .	380,144	39,807	212,467	25,527	..	..	248,059	30,301	..	..	116,699	10,273	..	..	..	..	95,236	5,496
Central India	..	..	..	..	..	..	Not reported.	1,246	..	..	..	..	..	..	..	..	..	..
Central Provinces.	..	..	..	..	..	..	97,972	6,503	..	..	..	..	..	..	..	..	1,285	69
Eastern Bengal and Assam.	..	..	..	..	..	..	102,913	13,405	..	..	..	..	..	..	..	..	..	..
Hyderabad	..	..	..	..	..	..	Not reported	5	..	..	Not reported.	2	..	..	..	..	..	1,066
Madras .	194,713	5,284	560,757	3,987	..	..	655,618	26,104	..	..	234,000	1,587	Not reported.	47	..	..	737,413	11,483 (a)
Punjab .	..	..	..	..	..	..	8.009	363	..	..	..	..	6,121	6,423	..	..	4,704	73
Rajputana .	..	..	..	..	..	..	8.714	157	1,857	1,292	308	36	..	..	..	..	..	..
United Provinces.	..	..	.	..	..	.	495	138	..	..		.	9,715	30	..	..	139,020	20,559
TOTAL .	577,565	45,486	790,717	31,701	266	121	1,149.554	84 871	1 857	1,292	397,962	20,396	16,850	8,073	623,543	1,484	1,524,460	53,022

(a) Represents the value of 733,739 tons only.

Copper. Two thousand and ninety-seven tons of copper-ore, valued at £2,911, were produced in Singhbhum during the year under review. This outturn is probably only the result of prospecting operations, and represents merely samples. In the Myitkyina district of Burma 159 tons of ore were obtained with a value of £493.

Corundum. There was a considerable increase in the output of corundum, which rose from 2,741 cwt. in 1910 to 1,804,522 cwt., valued at £1,675 in the year under review. With the exception of 185 cwt., the whole of this output came from Madras; 180 cwt. were produced in Rewa and 5 cwt. in Kashmir. The last-named output represents blue corundum and corundiferous rock from the sapphire mines.

Garnet. There was a decline in the output of garnet, which fell from 319½ cwt. in 1910 to 254½ cwt. in 1911. In the latter year, however, the value of the smaller output was £2,126 as against £1,885 for the larger quantity in the previous year.

Gypsum. There has been a considerable increase, amounting to nearly 50 per cent., in the amount of gypsum produced in India during the year under review. The output of Jamsar in Bikanir was practically unchanged, being 4,464 tons, valued at £168. There was also a slight fall in the amount produced in the Salt Range, the output being 1,469 tons as against 1,837 tons in the previous year. In the Delhi district of the Punjab, however, the increase was very considerable, from 450 tons in the year 1910 to 3,260 tons in 1911. The total value of the country's production during the year under review is returned as £2,308. This figure, however, is probably much too low, as the value returned for 1,309 tons produced in the Salt Range is only £7.

Monazite Active work has now begun on the monazite-bearing sands of the Travancore coast (see *Records, Geol. Surv., India*, Vol. XXXIX, p. 268), and 832 tons of monazite were obtained. The labour employed amounted on an average to 1,015 persons daily.

Ochre. The production of ochre in India fell off considerably during the year 1911, having dropped from 1,020 tons in the previous year to only 311 tons, valued at £34. Almost the whole of this decrease took place in Panna, which produced only 69 tons as against 815 tons in the previous year.

Samarskite.

Twenty-four cwt. of samarskite, valued at £89, were extracted during the year from the mica mines in Nellore. This mineral, which is essentially a niobate of uranium, yttrium and cerium, occurs sporadically associated with mica in the felspar of the pegmatites of the Nellore district. Its mode of occurrence has been described by Mr. G. H. Tipper in the previous volume of these *Records* (Vol. XLI, p. 210). A certain amount has been extracted with a view to its possible employment as a source of radium salts.

Steatite.

There was a considerable rise in the outturn of steatite, which increased from 4,897 cwt. in 1910 to 12,330 cwt. in the year under review. The increase was due to Jubbulpore, where the output rose from 3,068 cwt. to 8,816 cwt., and Karnul, which produced 3,320 cwt. as against 400 cwt. in the previous year. On the other hand, the Jhansi output decreased from 1,000 cwt. to 56 cwt., whilst no returns have been received from the old-established mines in the Minbu district of Burma. In spite of the greatly increased outturn, the total value is estimated at £1,225 or only £119 more than in the previous year.

IV.—MINERAL CONCESSIONS GRANTED.

TABLE 25.—*Statement of Mineral Concessions granted during 1911.*

BALUCHISTAN.

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Zhob .	(1) The Baluchistan Mining Syndicate.	Chromite . .	M. L. .	80	1st July 1911	30 years.
Do. . .	(2) Do. do. .	Do. . .	M. L. .	80	Do. .	Do.
Do. . .	(3) Do. do. .	Do. . .	M. L. .	80	Do. .	Do.
Do. . .	(4) Do. do. .	Do. . .	M. L. .	80	Do. .	Do.
Quetta . .	(5) Mr. Shiawakshaw Pherozeshaw of Quetta	Coal	M. L. .	73	Do. .	Do.
Do. . .	(6) Messrs. Allibhoy and Bros., Quetta.	Do.	M. L. .	57	Do. .	Do.
Do. . .	(7) The Baluchistan Coal Company, Limited, Karachi.	Do.	M. L. .	290	Do. .	Do.
Sibi . .	(8) Messrs. Rai Sahib Rocha Ram and Sons of Abbottabad.	Do.	M. L. .	80	Do. .	Do.
Do. . .	(9) Do. do. .	Do.	M. L. .	80	Do. .	Do.
Do. . .	(10) Do. do. .	Do.	M. L. .	80	Do. .	Do.
Do. . .	(11) Do. do. .	Do.	M. L. .	80	Do. .	Do.
Do. . .	(12) The Baluchistan Coal Company, Limited, Karachi.	Do.	M. L. .	2,560	Do. .	Do.
Do . .	(13) Do. do. .	Do.	M. L. .	160	Do. .	Do.

BENGAL.

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Hazaribagh .	(14) Babu Lachmi Narain Shroff.	Mica	M. L. .	40	13th September 1910.	30 years.
Do. .	(15) Mr. T. F. Milligan .	Do.	M. L. .	160	1st April 1904	Do.
Do. .	(16) Do. do. .	Do.	M. L. .	280	25th May 1903.	Do.
Do. .	(17) Mr. A. A. C. Dickson	Do.	P. L. .	46	24th January 1910.	1 year.
Do. .	(18) Babu Baidya Nath Saha	Do.	P. L. .	146·5	8th March 1911.	Do.
Do. .	(19) Babu Akhoy Kumar Gupta.	Do.	P. L. .	24·17	7th March 1911.	Do.
Do. .	(20) A. Jardine . .	Do. . .	P. L. .	119	2nd February 1911.	Do.
Do. .	(21) Mr. P. C. Andrews .	Do. . .	P. L. .	290	11th February 1911.	Do.

E. L.=*Exploring License.* P. L.=*Prospecting License.* M. L.=*Mining Lease.*

BENGAL—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Hazaribagh .	(22) Mr. C. Murray .	Mica	P. L. .	320	24th February 1911.	1 year.
Do. .	(23) Mr. A. Jardine .	Do.	P. L. .	80	20th March 1911.	Do.
Do. .	(24) Chota Nagpur Mica Syndicate, Ld.	Do.	M. L. .	1,086	1st November 1903.	30 years.
Do. .	(25) Do. do. .	Do.	M. L. .	40	1st April 1904	Do.
Do. .	(26) Mr. E. Lane . .	Do.	M. L. .	24	30th January 1910.	Do.
Do. .	(27) Do. do. .	Do.	M. L. .	150	6th December 1907.	Do.
Do. .	(28) Do. do. .	Do.	M. L. .	80	15th March 1909.	Do.
Do. .	(29) Messrs. Gladstone, Wyllie & Co.	Do.	M. L. .	240	18th May 1910.	Do.
Do. .	(30) Do. do. .	Do.	M. L. .	80	Do. .	Do.
Do. .	(31) Babu B. C. Bose .	Do.	M. L. .	246·5	6th May 1911	Do.
Do. .	(32) Satyendra Pada Sarkar.	Do.	M. L. .	120	Do. .	Do.
Do. .	(33) B. C. Bose . .	Do.	P. L. .	1·67	12th August 1911.	1 year.
Do. .	(34) Ananga Ranjan Chatterji.	Do.	P. L. .	240	8th August 1911.	Do.
Do. .	(35) Mr. A. Jardine .	Do. .	P. L. .	404·78	25th August 1911.	Do.
Do. .	(36) Mr. Shivji Walji .	Do.	P. L. .	80	8th September 1911.	Do.
Do. .	(37) Mr. C. A. Dickson .	Do.	P. L. .	200	5th August 1911.	Do.
Do. .	(38) Mr. J. W. Martin .	Do.	P. L. .	10	21st June 1911.	Do.
Do. .	(39) Babus Nogendra Nath Samanto and Satya Kinkar Sahana	Do.	P. L. .	320	28th June 1911.	Do.
Do. .	(40) Mr. Archibald A. C. Dickson.	Do.	M. L. .	320	6th June 1911	30 years
Do. .	(41) Mr. S. D. Philippe .	Do.	M. L. .	38	11th February 1911.	Do.
Sambalpur .	(42) Mr. A. H. Teitkins, Local Agent, Sambalpur.	Coal	P. L. .	424·38	14th December 1910.	2 years.
Do. .	(43) The Jubbalpur Prospecting Syndicate, Jubbalpur, C. P.	Gold, silver and lead.	M. L. .	49·14	1st July 1911	15 years.
Singhbhum .	(44) Messrs. Schröder, Smidt & Co. of Calcutta.	Chromite . .	P. L. .	About 3,891·2	12th June 1911.	1 year.

E. L.=*Exploring License.* P. L.=*Prospecting License.* M. L.=*Mining Lease.*

BOMBAY.

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Dhárwár	(45) Mr. Merwánji Sorábji Karáka.	Galena	P. L.	20	19th May 1911	1 year.
Do.	(46) Do. do.	Do.	P. L.	91	3rd July 1911	Do.
Kánara	(47) The Nágpur Manganese Mining Syndicate.	Manganese	E. L.	1,545	22nd December 1911.	Do.
Panch Maháls.	(48) Messrs. C. Chatoorbhooj and Co.	Do.	P. L.	1,196	26th January 1911.	Do.
Do.	(49) Do. do.	Do.	P. L.	251	Do.	Do.
Ratnágiri	(50) Mr. E. J. Beer for Jambon and Cie.	Manganese, iron and chromium.	P. L.	1,276	3rd May 1911	Up to 31st December 1912.

BURMA.

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Akyab	(51) Messrs. Ezekiel and Co.	Coal	M. L.	1,167	30th September 1910.	Up to 31st October 1932.
Do.	(52) The Hon'ble Babu Bhupendra Nath Basu.	Petroleum	P. L.	13,440	22nd November 1910.	1 year.
Do.	(53) Mr. Louis Grossman	Do.	P. L.	1,600	1st March 1911.	Do.
Do.	(54) Mr. J. M. Goodman	Do.	P. L.	2,560	17th May 1911.	Do.
Do.	(55) Do. do.	Do.	E. L.	12793·6	8th July 1911	Do.
Do.	(56) Do. do.	Do.	E. L.	9,984	Do.	Do.
Amherst	(57) Maung Paw	Lead, silver, copper, gold, etc.	P. L.	3,200	27th May 1911.	Do.
Do.	(58) Do. do.	All minerals (except oil).	P. L.	3,200	Do.	Do.
Do.	(59) Messrs. Shwe Oh Brothers & Co.	Do.	P. L.	3,200	18th August 1911.	Do.
Do.	(60) Maung Hpaw	Do.	P. L.	3,200	17th July 1911.	Do.
Do.	(61) Do. do.	Do.	P. L.	3,200	Do.	Do.
Do.	(62) Moti Raman	Do.	P. L.	3,200	29th August 1911.	Do.
Do.	(63) Col. S. G. Radcliff	Gold, silver, copper, tin, lead, etc.	P. L.	3,200	21st August 1911.	Do.
Do.	(64) Maung Hpaw	All minerals (except oil).	P. L.	3,200	17th July 1911.	Do.
Do.	(65) Messrs. Foucar and Co., Ltd.	Antimony	P. L.	309·14	4th September 1911.	Do.
Do.	(66) Moti Raman	All minerals (except oil).	P. L.	3,200	29th August 1911.	Do.
Do.	(67) Do. do.	Do.	P. L.	3,200	Do.	Do.

E. L.=*Exploring License.* P. L.=*Prospecting License.* M. L.=*Mining Lease.*

BURMA—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement	Term.
Amherst .	(68) Mr. C. E. Law .	All minerals (except oil).	P. L. .	2,816	18th September 1911.	1 year.
Do. .	(69) Maung Thein San .	Wolfram and allied minerals.	P. L. .	3,200	14th August 1911.	Do.
Do. .	(70) The Hon'ble Mr. Lim Chin Tsong .	All minerals (except oil).	P. L. .	6,400	29th August 1911.	Do.
Do. .	(71) Messrs. T. D'Castro and Sons.	All minerals (except mineral oil).	E. L. .	Amherst District except in Forest Reserves. Area not known.	10th August 1911.	Do.
Do. .	(72) Mr. A. A. Abreu .	All minerals (except oil).	P. L. .	560	20th October 1911.	Do.
Do. .	(73) Messrs. T. D Castro and Sons.	Do. .	P. L. .	1,280	14th November 1911.	Do.
Bhamo . .	(74) Mr. N. Samwell .	Gold . . .	P. L. .	1,600	20th September 1911.	Do.
Henzada .	(75) Mr. G. Mills . .	Petroleum . .	P. L. .	6,400	13th July 1911.	Do.
Do. . .	(76) Messrs. Osman Musti Khan and Co. . .	Do. . .	P. L. .	2,560	11th November 1911.	Do.
Do. . .	(77) The Indo-Burma Petroleum Co., Ltd.	Do. . .	P. L. .	7,680	30th October 1911.	Do.
Katha . .	(78) Mr. R. H. Pockling-ton.	Copper, gold, silver, lead, tin, iron, coal, asbestos, and zinc.	P. L. .	220	29th May 1911.	Do.
Do . .	(79) N. Khay Wai .	Lead, copper and gold.	E. L. .	2,560	22nd April 1911.	Do.
Do. . .	(80) Maung Tha E and five others.	Gold and ores .	E. L. .	1,280	29th May 1911.	Do.
Do. . .	(81) Maung Tun Man .	Gold, silver, copper and lead.	E. L. .	1,280	29th June 1911.	Do.
Do. . .	(82) Maung Nyo . .	Lead and silver .	P. L. .	960	8th July 1911.	Do.
Do. . .	(83) C. Soon Thin .	Lead . . .	P. L. . (renewal).	2,464	1st September 1911.	8 months.
Do. . .	(84) Upper Burma Mineral Prospecting Syndicate, Limited.	Gold, copper and lead.	P. L. .	2,560	21st November 1911.	1 year.
Lower Chindwin.	(85) Mr. J. W. Parry .	Minerals and mineral oil.	E. L. .	10,240	25th May 1911.	Do.
Do. .	(86) Do. do. .	Do. .	E. L. .	10,240	12th September 1911.	Do.
Magwe . .	(87) W. Mansfield & Co.	Petroleum . .	M. L. .	2,560	10th March 1911.	30 years.
Do. . .	(88) Maung Po Oh . .	Do. . .	P. L. .	208·10	10th April 1911.	1 year.

E. L.=*Exploring License.* P. L.=*Prospecting License.* M. L.=*Mining Lease.*

BURMA—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement	Term.
Magwe . .	(89) The Indo-Burma Petroleum Co., Ltd.	Petroleum . .	P. L. . (renewal).	1,280	9th March 1911.	1 year.
Do. . .	(90) Messrs. Finlay, Fleming & Co.	Do. . .	P. L. . (renewal).	2,240	19th February 1911.	Do.
Do. . .	(91) Yeo Eng Byan .	Do. . .	P. L. .	640	8th September 1911.	Do.
Do. . .	(92) Mr. H. P. Cameron .	Do. . .	P. L. .	2,240	Do. .	Do.
Do. . .	(93) The Burma Oil Co., Ltd.	Do. . .	P. L. . (renewal).	2,560	12th July 1911.	Do.
Do. . .	(94) Maung Tun Aung Gyaw.	Do. . .	P. L. .	3,160	14th June 1911.	Do.
Do. . .	(95) Burma Oil Co., Ltd.	Do. . .	M. L. . (renewal).	164 State wells Yenangyaung.	30th November 1911.	6 months.
Do. . .	(96) Ma Khin Le . .	Do. . .	P. L. .	383	29th April 1911.	1 year
Mandalay .	(97) Mr. Z. M. D'Silva .	Gold, copper, galena, coal, wolfram, antimony, aluminium and mica.	P. L. .	640	30th January 1911.	Do.
Do. .	(98) Mr. R. N. Iyer .	Lead and silver .	P. L. .	2,560	7th April 1911	Do.
Do. .	(99) Mr. E. Nisbet .	Galena, copper, gold and antimony.	E. L. .	4,800	30th March 1911.	Do.
Do. .	(100) Mr. W. Macdonald	Galena gold silver and copper.	P. L. . (renewal).	320	3rd May 1911.	Do.
Do. .	(101) Moola Dawood .	Gold silver lead copper and mica.	P. L. .	1,248·33	5th September 1911.	Do
Mergui . .	(102) Col. Radcliff .	Iron Pyrites .	P. L. .	3,200	1[illegible]th February 1911.	Do.
Do. . .	(103) Abdul Kader and Mahomed Baralla.	Tin, wolfram, gold and silver.	P. L. .	3,200	20th January 1911	Do.
Do. . .	(104) Tan Twan Tee for Messrs. Cheng Leo & Co.	All minerals (except oil).	E. L. .	Throughout Mergui District.	13th January 1911.	Do.
Do. . .	(105) Quah Chang Gwan	Do. .	E. L. .	Do. .	Do. .	Do.
Do. . .	(106) Quah Chang Gwan for Khoo Kim Cheng.	Do. .	E. L. .	Do. .	Do. .	Do.
Do. . .	(107) Mr. Charles Kitchen	Do. .	P. L. .	640	21st January 1911.	Do.
Do. . .	(108) Mr. J. N. Caldwell Adam.	Do. .	E. L. .	Throughout Mergui District.	6th April 1911	Do.
Do. . .	(109) Mr. H. J. Davis for Finlay, Fleming & Co.	Do. .	E. L. .	Do.	9th May 1911	Do.

E. L.—*Exploring License.* P. L.—*Prospecting License.* M. L.—*Mining Lease.*

BURMA—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Mergui . .	(110) Ma Han Mi . .	All minerals (except oil).	E. L. .	Throughout Mergui District.	13th May 1911.	1 year.
Do. . .	(111) Mr. H. Sherback for Bume and Reif.	Do. .	P. L. .	1,920	12th June 1911.	Do.
Do. . .	(112) U Tha Dun Aung .	Do. .	E. L. .	Throughout Mergui District.	15th June 1911.	Do.
Do. . .	(113) Ban Swee Seng & Co.	Tin, gold, copper and wolfram.	P. L. .	2,764·80	3rd August 1911.	Do.
Do. . .	(114) Sit Khwet . .	All minerals (except oil).	P. L. .	1,988·98	2nd September 1911.	Do.
Do. . .	(115) A. Jalil . .	Do. .	P. L. .	3,200	19th August 1911.	Do.
Do. . .	(116) Maung Shwe Yeik.	Do. .	P. L. .	3,200	19th July 1911.	Do.
Do. . .	(117) Sit Shoo and Oo Ghine.	Do. .	P. L. .	3,192·32	6th July 1911	Do.
Do. . .	(118) C. Boon Khoon .	Do. .	P. L. .	3,186·00	2nd August 1911.	Do
Do. . .	(119) Sit Shoo and Oo Ghine.	Do. .	P. L. .	1,246·72	31st July 1911.	Do.
Do. . .	(120) Sit Shu . .	Do. .	P. L. .	3,200	31st August 1911.	Do.
Do. . .	(121) Saw Leng Lee .	Do. .	P. L. .	660·48	2nd September 1911.	Do.
Do. . .	(122) Messrs. Mower & Co.	Do. .	P. L. . (renewal).	2,560	1st July 1911	Do.
Do. . .	(123) Do. do. .	Do. .	P. L. . (renewal).	80	Do. .	Do.
Do. . .	(124) Do. do. .	Do. .	P. L. .	2,240	Do. .	Do.
Do. . .	(125) Maung Saw Maung	Do. .	P. L. .	3,055	19th July 1911.	Do.
Do. . .	(126) Tan Gun Haung .	Do. .	P. L. .	596·48	24th August 1911.	Do.
Do. . .	(127) Maung Kya Sin .	Do.	P. L. .	3,200	14th September 1911.	Do.
Do. . .	(128) Maung Shwe Yun .	Wolfram and allied minerals.	P. L. .	3,200	2nd September 1911.	Do.
Do. . .	(129) C. Boon Khoon .	All minerals (except oil).	P. L. .	2,949	22nd July 1911.	Do.
Do. . .	(130) Chia Boon Teat .	Do.	E. L. .	Throughout Mergui District.	13th July 1911.	Do.
Do. . .	(131) Maung Kya Sin .	Wolfram, gold, tin and allied metals.	P. L. .	3,200	15th September 1911.	Do.

E. L. =*Exploring License.* P. L.=*Prospecting License.* M. L.=*Mining Lease.*

BURMA—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Mergui . .	(132) Maung Tocin Pe .	All minerals except oil.	E. L. .	Throughout Mergui District.	15th September 1911.	1 year.
Do. . .	(133) Mr. A. E. Landon White.	Coal . . .	P. L. (renewal).	2,346·7	1st August 1911.	Do.
Do. . .	(134) Maung Shwe Yeik.	All minerals (except oil).	P. L. .	2,304	21st December 1911.	Do.
Do. . .	(135) Do. do. .	Do. .	P. L. .	2,406·20	11th November 1911.	Do.
Do. . .	(136) Do. do. .	Do. .	P. L. .	3,200	1st November 1911.	Do.
Do. . .	(137) Do. do. .	Do. .	P. L. .	714·56	21st December 1911.	Do.
Do. . .	(138) Maung Shwe Thi .	Do. .	P. L. .	896	5th October 1911.	Do.
Do. . .	(139) Mr. H. Sherback for Messrs. Bume and Reif.	Do. .	P. L. .	1,902·08	10th November 1911. .	Do.
Do. . .	(140) Do. do. .	Do. .	P. L. .	2,775·04	Do. .	Do.
Do. . .	(141) Do. do. .	Do. .	P. L. .	2,396·16	Do. .	Do.
Do. . .	(142) Maung Thi . .	Do. .	P. L. .	8,160	2nd October 1911.	Do.
Do. . .	(143) Chia Boon Teat .	Do. .	P. L. .	3,200	3rd November 1911.	Do.
Do. . .	(144) U Tha Dun 'Aung and Maung Shwe Don.	Do. .	P. L. .	3,200	4th December 1911.	Do.
Do. . .	(145) Maung Shwe I .	Do. .	P. L. .	1,423·36	30th October 1911.	Do.
Do. . .	(146) Messrs. Finlay, Fleming & Co.	Do. .	P. L. .	2,189	15th December 1911.	Do.
Do. . .	(147) Do. do. .	Do. .	P. L. .	2,880	Do. .	Do.
Do. . .	(148) Messrs. Bume and Reif.	Do. .	P. L. .	3,038·72	10th November 1911.	Do.
Do. . .	(149) Hadji Mahomed Ismail.	Do. .	P. L. .	3,200	7th November 1911.	Do.
Do. . .	(150) Messrs. Finlay, Fleming & Co.	Do. .	P. L. .	3,200	15th December 1911.	Do.
Do. . .	(151) Saw Long Lee .	Do. .	P. L. .	3,200	5th December 1911.	Do.
Do. . .	(152) Eu Shwe Swai .	Do. .	P. L. .	1,960	9th November 1911.	Do.
Do. . .	(153) E. Ahmed . .	Gold, tin, wolfram and allied metals.	P. L. .	2,316·80	31st October 1911.	Do.
Do. . .	(154) Maung Thein Pe .	All minerals (except oil).	P. L. .	1,260·52	9th November 1911.	Do.
Do. . .	(155) Messrs. Bume and Reif.	Do. .	P. L. .	619·52	10th November 1911.	Do.

BURMA—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Mergui . .	(156) Messrs. Bume and Reif.	All minerals (except oil).	P. L. .	1,356·80	10th November 1911.	1 year.
Do. . .	(157) Do. do. .	Do. .	P. L. .	1,536	Do. .	Do.
Do. . .	(158) Do. do. .	Do. .	P. L. .	1,064·91	Do. .	Do.
Do. . .	(159) Do. do. .	Do. .	P. L. .	1,518·08	Do. .	Do.
Do. . .	(160) Do. do. .	Do. .	P. L. .	1,638·40	Do. .	Do.
Do. . .	(161) Do. do. .	Do. .	P. L. .	1,477·12	Do. .	Do.
Do. . .	(162) Maung Kyaw .	Do. .	P. L. .	2,151·40	15th November 1911.	Do.
Do. . .	(163) M. E. Bymiah .	Wolfram and iron	P. L. .	2,135·04	5th December 1911	Do.
Do. . .	(164) Mr. Charles Kitchin	Wolfram, tin, and copper.	P. L. (renewal).	302 08	30th September 1911.	Do.
Do. . .	(165) Ma In Ngon .	All minerals (except oil).	P. L. .	2,088·96	13th November 1911	Do.
Do. . .	(166) Maung Kyaw .	Do. .	P. L. .	1,041·90	20th November 1911.	Do.
Do. . .	(167) C. Boon Khoon .	Do. .	P. L. .	983·04	5th December 1911.	Do.
Do. . .	(168) Ma In Ngon .	Do. .	P. L. .	3,200	4th December 1911.	Do.
Minbu . .	(169) Maung Wa Byaw, Maung Sit Hmaw and Maung Taik Gyi.	Petroleum . .	P. L. .	261·47	22nd March 1911.	Do.
Do. . .	(170) Shamuddin . .	Do. .	E. L. .	8,640	10th January 1911.	Do.
Do. . .	(171) Messrs. Moola Dawood Sons & Co.	Do. . .	P. L.	2,880	1st March 1911.	Do.
Do. . .	(172) Onmarji . .	Do. . .	P. L. .	640	7th January 1911.	Do.
Do. . .	(173) Shamuddin . .	Do. . .	P. L. .	1,280	24th February 1911.	Do.
Do. . .	(174) Yeo Eng Byan .	Do. . .	P. L. .	2,880	18th May 1911.	Do.
Do. . .	(175) The Irrawaddy Oil Syndicate.	Do. . .	P. L. .	1,920	1st October 1911.	Do.
Do. . .	(176) Sulaiman Adamji .	Do. . .	P. L. (renewal).	3,995 52	20th January 1911.	Do.
Do. . .	(177) Shamuddin . .	Do. . .	P. L. .	661·58	1st March 1911.	Do.
Do. . .	(178) Messrs. Finlay, Fleming & Co.	Do. . .	P. L. .	960	1st May 1911.	Do.
Do. . .	(179) The British Burma Petroleum Co., Ltd.	Do. . .	P. L. .	614·4	14th September 1911.	Do.
Do. . .	(180) Maung U . .	Do. . .	P. L. .	2,720	16th August 1911.	Do.

E. L.—*Exploring License.* P. L.—*Prospecting License.* M. L.—*Mining Lease.*

BURMA—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Minbu . .	(181) Maung Ne Dun .	Petroleum . .	P. L. .	5,440	27th July 1911.	1 year.
Do. . .	(182) Mr. Fenton . .	Do. . .	P. L. .	2,560	27th August 1911.	Do.
Do. . .	(183) Maung Thu Wa .	Do. . .	P. L. .	640	8th July 1911.	Do.
Do. . .	(184) Sulaiman Adamji .	Do. . .	P. L. .	2,520	26th August 1911.	Do.
Do. . .	(185) Maung Hla Gyaw .	Do. . .	P. L. .	100	27th August 1911.	Do.
Do. . .	(186) Maung Po San, Maung Lu Dok and Maung Ya Paing.	Do. . .	P. L. .	1,664	26th October 1911.	Do.
Do. . .	(187) Mr. H. P. Cameron	Do . .	P. L. .	1,920	25th October 1911.	Do.
Do. . .	(188) Maung Pan Bu .	Do. . .	P. L. .	960	16th November 1911.	Do.
Do. . .	(189) Tar Mahomed Ismail.	Do. . .	P. L. .	2,880	5th January 1912.	Do.
Myingyan .	(190) Messrs. Stewart Raeburn & Co.	Do . .	P. L. .	5,120	3rd January 1911.	Do.
Do. .	(191) Messrs. Shwe Oh Bros & Co.	Do. . .	P. L. .	800	Do. .	Do.
Do. .	(192) Mr. Walter Mansfield.	Do. . .	M. L. .	1,920	6th March 1911.	30 years.
Do. .	(193) The Rangoon Oil Co. Ltd.	Do. . .	P. L. .	640	18th January 1911.	1 year.
Do. .	(194) The Burma Oil Co., Ltd	Do. . .	P. L. .	1,280	15th September 1910.	Do.
Do. .	(195) The Rangoon Oil Co., Ltd.	Do. . .	P. L. .	640	15th February 1910.	Do.
Do. .	(196) Messrs. Shwe Oh Bros. & Co.	Do. . .	P. L. .	821·01	25th February 1911.	Do.
Do. .	(197) Mr. A. H. Tucker .	Do. . .	P. L. .	1,280	23rd March 1911.	Do.
Do. .	(198) The Burma Oil Co., Ltd.	Do. . .	P. L. .	1,320	28th January 1911.	Do.
Do. .	(199) Maung Po Kin .	Do. . .	P. L. .	483·35	23rd June 1911.	Do.
Do. .	(200) Moolla Ahmed .	Do. . .	P. L. (renewal).	640	5th May 1911.	Do.
Do. .	(201) The Burma Oil Co., Ltd.	Do. . .	P. L. (renewal).	7,680	1st May 1911.	Do.
Do. .	(202) Yeo Eng Byan .	Do. . .	P. L. .	640	15th July 1911	Do.
Do. .	(203) Mr. L. A. Maing .	Do. . .	P. L. .	640	25th September 1911.	Do.

E. L.=*Exploring License.* P. L.=*Prospecting License.* M. L.=*Mining Lease.*

BURMA—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Myingyan .	(204) Maung Maung Aw .	Petroleum . .	P. L. .	795·59	22nd December 1911.	1 year.
Do. .	(205) Mr. Moolla Ahmed.	Do. . .	P. L. .	1,280	29th May 1911.	Do.
Do. .	(206) The Burmah Oil Co., Ltd	Do. . .	P. L. .	1,280	15th September 1911.	Do.
Do. .	(207) Mr. Sulaiman Adamjee.	Do. . .	P. L. .	1,280	13th August 1911.	Do.
Do. .	(208) Do. do. .	Do. . .	P. L. .	320	Do. .	Do.
Northern Shan States.	(209) Mr. W. R. Hillier .	Copper and allied metals.	P. L. .	2,560	27th June 1911.	Do
Do. .	(210) Do. do. .	Galena and allied ores.	E. L. .	Not stated .	Do. .	Do.
Do. .	(211) Mr. A. R. Oberlander.	Silver, lead, iron and copper.	P. L. . (renewal).	3,200 .	4th November 1911.	Do.
Pakôkku .	(212) Maung Maung Gyi and two others.	Petroleum . .	M. L .	1,280 .	18th March 1911	30 years.
Do. .	(213) Maung Aung Ba .	Do. . .	P. L. .	2,240 .	16th January 1911.	1 year.
Do. .	(214) Maung Shwe Goh .	Do. . .	P. L. . (renewal).	Blocks Nos. 21 and 62 Yenangyat.	12th January 1911.	Do.
Do. .	(215) Mr. M. Goolam Hussein.	Do. . .	P. L. . (renewal).	1,280	30th January 1911.	Do.
Do. .	(216) Maung Shwe Goh .	Do. . .	P. L. . (renewal).	Block Nos. 5, 6, 8 and eastern half of No. 7.	12th January 1911.	Do
Do. .	(217) Messrs. Moolla Dawood, Sons & Co.	Do. . .	P. L. .	Block No. 56 and 4¼ sq. miles N. and adjoining Blocks 137, 138 and 139.	14th March 1910.	Do.
Do. .	(218) Maung U Kaing .	Do. . .	E. L. .	6,400	20th February 1911.	Do.
Do. .	(219) Do. do. .	Do. . .	E. L. . (renewal).	1,280	24th January 1911.	Do
Do. .	(220) Do. do. .	Do. . .	E. L. .	3,200	30th March 1911.	Do.
Do. .	(221) Messrs. Mower & Co., Agents, Rangoon Oil Co., Ltd.	Do. . .	P. L. .	261	23rd May 1911.	Do.
Do. .	(222) Mr. H. Watson .	Do. . .	P. L. .	3,200	29th April 1911.	Do.
Do. .	(223) Mr. R. P. Wilcox, Agent for Mr. W. Mansfield.	Do. . .	M. L. .	Blocks Nos. 119 and 121.	11th March 1911.	30 years.

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BURMA—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Pakôkku	(224) Sulaiman Adamji.	Petroleum	P. L.	Blocks Nos. 14, 28 and 70 Yenangyat.	12th September 1911.	1 year.
Do.	(225) The Burma Oil Co., Ltd.	Do.	P. L.	Block No. D 2.	25th July 1911.	Do.
Do.	(226) Maung Ba Thaik	Do.	P. L.	3,200	25th September 1911.	Do.
Do.	(227) Maung U Kaing	Do.	P. L.	3,200	26th September 1911.	Do.
Do.	(228) The Burma Oil Co., Ltd.	Do.	P. L. (second renewal).	Block No. 138	28th September 1911.	Do.
Do.	(229) The Rangoon Oil Co.	Do.	P. L. (renewal).	Block No. 12.	22nd September 1911.	Do.
Do.	(230) Mr. Hajee Hashim Hajee Khan Mahomed.	Do.	P. L.	2,240	6th December 1911.	Do.
Do.	(231) Abdool Shakoor Abdool Gunny.	Do.	P. L.	1,920	30th October 1911.	Do.
Do.	(232) The Indo-Burma Petroleum Co., Ltd.	Do.	P. L.	640	24th November 1911.	Do.
Do.	(233) Do. do.	Do.	P. L.	248	Do.	Do.
Do.	(234) Nath Singh Oil Co., Ltd.	Do.	P. L.	1,280	5th December 1911.	Do.
Do.	(235) Ko Bah Oh and Co.	Do.	P. L.	Block No. 29 Yenangyat.	28th November 1911.	Do.
Do.	(236) Mr. W. Mansfield	Do.	P. L. (renewal).	Blocks Nos. 122 and 137 Yenangyat.	5th October 1911.	Do.
Pegu	(237) Mr. W. R. Fox	Gold and tin	P. L.	5,670·4	3rd February 1911.	Do.
Prome	(238) Mr. W. B. E. Rule.	Petroleum	P. L. (renewal).	10,496	3rd June 1910.	Do.
Do.	(239) Maung Tun Aung Kyaw.	Do.	E. L.	46,080	20th February 1911.	Do.
Do.	(240) Maung Shwe Zin, Agent for Messrs. Shwe Oh Bros. & Co.	Do.	P. L.	1,824	5th April 1911.	Do.
Do.	(241) Mr. Sarkies	Do.	P. L.	211 84	26th April 1911.	Do.
Do.	(242) Mr. D. Lister James, Agent for Burma Oil Co., Ltd.	Do.	P. L.	3,200	31st May 1911.	Do.
Do.	(243) Maung Shwe Zin, Agent for Shwe Oh Bros. & Co.	Do.	P. L.	3,072	20th May 1911.	Do.
Do.	(244) Mr. R. P. Wilcox Agent for Mr. Walter Mansfield.	Do.	P. L.	2,560	9th June 1911	Do.

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BURMA—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Prome . .	(245) Maung Pe . .	Petroleum . .	P. L. .	121·6	9th May 1911.	1 year.
Do. . .	(246) Mr. H. A. Foy .	Do. . .	P. L. .	8·37	11th September 1911.	Do.
Do. . .	(247) Maung Thu Daw .	Do. . .	P. L. .	1,344	11th July 1911.	Do.
Do. . .	(248) Maung Tun Aung Gyaw.	Do . .	E. L. .	10,240	1st July 1911.	Do.
Do. . .	(249) Maung Pe . .	Do. . .	P. L. .	1,280	25th September 1911.	Do.
Ruby Mines .	(250) Mr. W. Macdonald.	Metalliferous minerals.	P. L. .	320	1st January 1911.	Do.
Do. .	(251) The Hon'ble Mr. Lim Chin Tsong.	Copper, lead and iron ores.	P. L. .	640	1st March 1911.	Do.
Do. .	(252) Maung Nya Na .	Rubies . .	E. L. .	1,305·6	8th August 1911.	Do.
Sagaing .	(253) Mr. Gerard Lovell.	Iron ore . .	P. L. .	231·73	9th February 1911.	Do.
Salween .	(254) The Hon'ble Mr. Lim Chin Tsong.	Asbestos . .	P. L. .	3,968	24th May 1911.	Do.
Do. . .	(255) Mr. W. J. Cotterell	Gold . . .	P. L. .	3,200	25th August 1911.	Do.
Do. . .	(256) Mr H. A Foy .	Wolfram . .	P. L. .	3,200	11th September 1911.	Do.
Do. . .	(257) Do. do. .	Do. . .	P. L. .	3,200	30th October 1911.	Do.
Shwebo .	(258) Mr. E. S. Attia .	Petroleum . .	P. L. .	1,920	31st May 1911	Do.
Do. . .	(259) Do. do. .	Do . .	P. L.	3,200	21st April 1911.	Do.
Do. . .	(260) The Indo-Burma Petroleum Co., Ltd.	Do. . .	P. L. .	1,280	25th May 1911.	Do.
Do. . .	(261) The Indo-Burma Petroleum Co., Ltd.	Do. . .	P. L. .	5,120	19th September 1911.	Do.
Southern Shan States.	(262) Mr. B. G. Roberts on behalf of the Dewalachi Galena Syndicate.	Coal . . .	P. L. .	7,360	23rd February 1911.	Do.
Do. .	(263) Mr. A. C. Martin .	Copper and allied minerals.	P. L. .	3,120	3rd March 1911.	Do.
Do. .	(264) Mr. J. Dumoulin .	Gold, copper and other minerals.	P. L. .	2,400	31st March 1911.	Do.
Do. .	(265) Messrs. Foucar and Co.	All minerals (except oil).	P. L. .	1,120	17th January 1911.	Do.
Do. .	(266) Messrs. A. C. Martin and C. H. DePaulsen.	All minerals (except mineral oil).	P. L. .	3,200	16th March 1911.	Do.
Do. .	(267) Messrs. A. C. Martin and C. H. DePaulsen.	Do. .	P. L. .	3,200	20th June 1911.	Do.

E. L.=*Exploring License.* P. L.=*Prospecting License.* *M. L.=Mining Lease.*

BURMA—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Southern Shan States.	(268) Mr. N. Samwell	Gold, copper, tin and allied minerals.	P. L.	3,200	26th June 1911.	1 year.
Do.	(269) Mr. D. K. Macdonald.	Lead	P. L.	1,120	15th May 1911	Do.
Do.	(270) Mr. A. R. H. Ady	All minerals (except oil).	P. L. (renewal).	2,560	26th April 1911.	Do.
Do.	(271) Mr. D. E. Smyth	Copper	P. L.	3,200	8th June 1911.	Do.
Do.	(272) Mr. F. H. Parry on behalf of Dewalachi Galena Syndicate.	Lead, copper and other minerals (except oil).	P. L. (renewal).	3,200	15th January 1911.	Do.
Do.	(273) Mr. D. E. Smyth	Coal	P. L.	3,200	8th June 1911	Do.
Do.	(274) The Southern Shan States Syndicate (1909), Ltd.	Minerals and mineral oil.	P. L. (renewal).	A strip of land measuring 25 miles in an air line or to the limit of British territory, whichever is nearer on either side of the Salween river.	4th December 1911.	4 years.
Do.	(275) Maung Yaing	Silver and lead	P. L.	400	20th July 1911.	1 year.
Do.	(276) Lieut.-Col. G. Rippon.	Copper, lead, iron, antimony and associated minerals.	P. L.	3,200	28th August 1911.	Do.
Do.	(277) Mr. C. H. DePaulsen.	All minerals (except oil).	P. L.	1,440	3rd August 1911.	Do.
Do.	(278) Lieut.-Col. G. Rippon.	Tin, wolfram and associated minerals.	P. L.	2,560	29th August 1911.	Do.
Do.	(279) The Hon'ble Mr. Lim Chin Tsong.	All minerals (except oil).	P. L.	2,120	27th October 1911.	Do.
Do.	(280) Mr. W. R. Hillier	Antimony and other ores.	P. L.	960	23rd October 1911.	Do.
Do.	(281) Do. do.	All minerals	E. L.	Not known	Do.	Do.
Do.	(282) Do. do.	Do.	E. L.	17,920	Do.	Do.
Do.	(283) Mr. F. H. Parry on behalf of Dewalachi Galena Syndicate.	Lead, copper, and other minerals.	P. L. (renewal).	3,200	29th June 1911.	Do.
Tavoy	(284) Messrs. Radcliff & Co.	All minerals (except oil).	P. L.	2,722	23rd March 1911.	Do.
Do.	(285) Mr. R. B. Levien	Do.	P. L.	1,885	9th January 1911.	Do.
Do.	(286) C. Sein Thin	Do.	P. L.	2,306	4th January 1911.	Do.

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BURMA—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Tavoy . .	(287) Ma Mo Thu . .	All minerals (except oil).	P. L. .	2,462	7th January 1911.	1 year.
Do. . .	(288) Messrs. Shwe Oh Bros. & Co.	Do. .	P. L. .	1,280	4th January 1911.	Do.
Do. . .	(289) Do. do. .	Do. .	P. L. .	1,120	Do.	Do.
Do. . .	(290) Do. do. .	Do. .	P. L. .	1,280	Do. .	Do.
Do. . .	(291) Ung Kyi Pe Bros. & Co.	Do. .	P. L. .	1,603	17th March 1911.	Do.
Do. . .	(292) Tan Po Chong .	Do. .	P. L. .	3,182	25th March 1911.	Do.
Do. . .	(293) Mr. P. P. Murphy	Do. .	P. L. .	667	31st January 1911.	Do.
Do. . .	(294) Chu Lu Yin . .	Do. .	P. L. .	2,947	4th January 1911.	Do.
Do. . .	(295) Messrs. Shwe Oh Bros. & Co. . .	Do. .	P. L. .	3,200	Do. .	Do.
Do. . .	(296) Khoo Kim Cheng .	Do. .	P. L. .	3,200	Do. .	Do.
Do. . .	(297) Maung Shwe Pu .	Do. .	P. L. .	8,200	Do. .	Do.
Do. . .	(298) Maung Hpaw .	Do. .	P. L. .	3,200	7th January 1911.	Do.
Do. . .	(299) The Hon'ble Mr. Lim Chin Tsong.	Do. .	P. L. .	1,580	4th January 1911.	Do.
Do. . .	(300) Maung Hpaw .	Do. .	P. L. .	2,560	24th January 1911.	Do.
Do. . .	(301) H. Fakeer Mahomed.	Do. .	P. L. .	1,280	21st January 1911.	Do.
Do. . .	(302) Mr. B. C. Simeons.	Do. .	P. L. .	656	18th January 1911.	Do.
Do. . .	(303) The Hindu Chaung Tin Dredging and Mining Co., Ltd.	Do. .	P. L. . (renewal).	3,200	16th February 1911.	6 months.
Do. . .	(304) Thi Shwe zin .	Do. .	P. L. .	31	15th March 1911.	1 year.
Do. . .	(305) Mr. R. B. Levien .	Do. .	P. L. .	3,200	22nd May 1911.	Do.
Do. . .	(306) M. A. Sooratee .	Do. .	P. L. .	2,900	1st April 1911.	Do.
Do. . .	(307) Teong Shwe Sin .	Do. .	P. L. .	3,085	27th May 1911.	Do.
Do. . .	(308) Ung Kyi Pe Bros. & Co.	Do. .	P. L. .	1,805	1st June 1911.	Do.
Do. .	(309) Teong Swee Sin .	Do. .	P. L. .	2,116·50	12th May 1911.	Do.
Do. . .	(310) The Hitakaree & Co.	Do. .	P. L. .	2,755	27th May 1911.	Do.
Do. . .	(311) Chu Lu yin . .	Do. .	P. L. .	2,572	1st April 1911	Do.

E. L.=*Exploring License.* P. L.=*Prospecting License.* M. L.=*Mining Lease.*

BURMA—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Tavoy . .	(312) Chu Lu Yin. .	All minerals (except oil).	P. L. .	3,200	30th June 1911.	1 year.
Do. . .	(313) The Hitakaree & Co.	Do. .	P. L. .	3,146	27th May 1911.	Do.
Do. . .	(314) Ung Kyi Pe Bros. & Co.	Do. .	P. L. .	1,166·60	1st April 1911.	Do.
Do. . .	(315) Chu Lu Yin .	Do. .	P. L. .	3,176·96	Do. .	Do.
Do. . .	(316) Maung Pet . .	Do. .	P. L. .	890·50	27th May 1911.	Do.
Do. . .	(317) Messrs. Shwe Oh Bros. & Co.	Do. .	P. L. .	2,880	24th May 1911.	Do.
Do. . .	(318) Maung Pet . .	Do. .	P. L. .	1,280	22nd April 1911.	Do.
Do. . .	(319) Kyong Nga . .	Do. .	P. L. .	2,880	8th May 1911	Do.
Do. . .	(320) Quah Cheng Gwan	Do. .	P. L. .	1,274	13th June 1911.	Do.
Do. . .	(321) Maung Min Gyaw Bros. & Co.	Do. .	P. L. .	1,496	9th June 1911.	Do.
Do. . .	(322) Ong Hoe Kyin .	Do. .	P. L. .	2,622	13th May 1911.	Do.
Do. . .	(323) Ma Dwe . .	Do. .	P. L. .	1,719·40	12th June 1911.	Do.
Do. . .	(324) Eu Shwe Swe .	Do. .	P. L. .	3,029	1st April 1911	Do.
Do. . .	(325) Maung Hpaw .	Do. .	P. L. .	358·88	28th June 1911.	Do.
Do. . .	(326) Kyong nga . .	Do. .	P. L. .	2 582	27th May 1911.	Do.
Do. . .	(327) Khoo Shwe Gun .	Do. .	P. L. .	1,216	1st April 1911	Do.
Do. . .	(328) Lim Kin Seng Bros. & Co.	Do. .	P. L. .	1,201·20	28th June 1911.	Do.
Do. . .	(329) Swee Seng & Co. .	Do. .	P. L. .	502	30th May 1911.	Do.
Do. . .	(330) Maung Hpaw .	Do. .	P. L. .	502	10th June 1911.	Do.
Do. . .	(331) Lim Chin Tsong .	Do.	P. L. .	282	2nd June 1911.	Do.
Do. . .	(332) Do. do. .	Do. .	P. L. .	3,160 80	17th June 1911.	Do.
Do. . .	(333) San Saing Tin .	Do. .	P. L. .	1,955	13th June 1911.	Do.
Do. . .	(334) Khoo Zun Nee .	Do. .	P. L. .	2 688	13th May 1911.	Do
Do. . .	(335) Swan Huat & Co. .	Do. .	P. L. .	1,283	24th May 1911.	Do.

E. L.=*Exploring License.* P. L.=*Prospecting License.* M. L.=*Mining Lease.*

BURMA—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Tavoy . .	(336) Lim Kim Seng Bros. & Co	All minerals (except oil).	P. L. .	1,900	27th May 1911.	1 year.
Do. . .	(337) Swee Seng & Co. .	Do. .	P. L. .	482	30th May 1911.	Do.
Do. . .	(338) Ko Maung Gyi .	Do. .	P. L. .	2,917·8	30th June 1911.	Do.
Do. . .	(339) Chip Seng & Co. .	Do. .	P. L. .	646	18th June 1911.	Do.
Do. . .	(340) Ma Sein Daing .	Do. .	P. L. .	1,833	13th May 1911.	Do.
Do. . .	(341) Maung Dwe .	Do. .	P. L. .	1,440	12th June 1911.	Do.
Do. . .	(342) Byan Moh & Co. .	Do. .	P. L. .	2,598	7th June 1911	Do.
Do. . .	(343) Ong Hoe Kyin .	Do. .	P. L. .	2,744	13th June 1911.	Do.
Do. . .	(344) Ma Sein Daing .	Do. .	P. L. .	1,244	1st April 1911	Do.
Do. . .	(345) Ma Thaw . .	Do. .	P. L. .	2,800	13th May 1911.	Do.
Do. . .	(346) Mr. T. J. Mackay .	Do .	P. L. .	2,856	22nd May 1911.	Do.
Do. . .	(347) Maung Dwe .	Do. .	P. L. .	3,176	1st May 1911	Do.
Do. . .	(348) The Tavoy Concessions, Ltd	Do. .	P. L. .	3,200	1st July 1911	Do.
Do. . .	(349) Do do. .	Do. .	P. L. .	3,200	31st August 1911	Do.
Do. . .	(350) Quah Cheng Gwan	Do. .	P. L. .	827·36	23rd August 1911.	Do.
Do. . .	(351) Khoo Tun Byan .	Do. .	P. L. .	2,300	19th August 1911.	Do.
Do. . .	(352) Lim Kyee Yan Bros. & Co.	Do. .	P. L. .	3,195	1st July 1911	Do.
Do. . .	(353) San Saing Tin .	Do. .	P. L. .	1,282·30	2nd September 1911.	Do.
Do. . .	(354) Ong Hoe Kyin .	Do. .	P. L. .	2,797·12	19th August 1911.	Do.
Do. . .	(355) Khoo Zun Nee .	Do. .	P. L. .	3,200	1st July 1911	Do.
Do. . .	(356) The Tenasserim Concessions, Ltd.	Do. .	P. L. .	2,734·03	19th August 1911.	Do.
Do. . .	(357) Maung Pet . .	Do. .	P. L. .	3,022·40	23rd August 1911.	Do.
Do. . .	(358) Khoo Tun Byan .	Do .	P. L. .	3,086	1st July 1911	Do.
Do. . .	(359) Maung Ni . .	Do. .	P. L. .	848·64	8th September 1911.	Do.
Do. . .	(360) Maung Shwe Mya	Do. .	P. L. .	880	29th August 1911	Do.

E. L.=*Exploring License.* P. L.=*Prospecting License.* M. L.=*Mining Lease.*

BURMA—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Tavoy . .	(361) Maung Pet .	All minerals (except oil).	P. L. .	2,015·60	23rd August 1911.	1 year.
Do. . .	(362) Fakeer Mahomed .	Do. .	P. L. .	2,900	1st July 1911	Do.
Do. . .	(363) Chu Lu Yin . .	Do. .	P. L. .	1,416	17th July 1911.	Do.
Do. .	(364) The Rangoon Mining Co., Ltd.	Do. .	P. L. .	3,200	22nd July 1911.	Do.
Do. . .	(365) Messrs. Ba Thuang Bros. & Co.	Do. .	P. L. .	2,370·3	1st August 1911.	Do.
Do. . .	(366) Maung E Cho .	Do. .	P. L. .	3,168·69	17th July 1911.	Do.
Do. . .	(367) San Saing Tin .	Do. .	P. L. .	1,625·10	8th September 1911.	Do.
Do. . .	(368) Swan Huat & Co. .	Do. .	P. L. .	1,637·84	10th August 1911.	Do.
Do. . .	(369) Ko Maung Gyi .	Do. .	P. L. .	1,316·4	11th August 1911.	Do.
Do. . .	(370) Maung Ni To .	Do. .	P. L. .	2,410	28th July 1911.	Do.
Do. . .	(371) Khoo Sin Haing .	Do. .	P. L. .	1,280	3rd July 1911.	Do.
Do. . .	(372) Khoo Jin Taik .	Do. .	P. L. .	2,330·88	30th August 1911.	Do.
Do. . .	(373) Mr. C. A. Meredith	Do. .	P. L. .	3,072	19th August 1911.	Do.
Do. .	(374) Maung Ni To .	Do. .	P. L. .	3,172·64	2nd September 1911.	Do.
Do. . .	(375) Lim Kyee Yan .	Do. .	P. L. .	1,420·80	19th August 1911.	Do.
Do. . .	(376) M. A. Sooratee .	Do. .	P. L.	1,225·12	Do. .	Do.
Do. . .	(377) Kyong Nga . .	Do. .	P. L. .	2,376	Do. .	Do.
Do. . .	(378) The Hitakaree & Co.	Do. .	P. L. .	2,921·20	6th September 1911.	Do.
Do. . .	(379) Tan Shwe Cho .	Do. .	P. L. .	2,076·10	31st August 1911.	Do.
Do. . .	(380) Teong Shwe Sin .	Do. .	P. L. .	3,200	5th September 1911.	Do.
Do. . .	(381) Mr. P. P. Murphy	Do. .	P. L. .	2,256·66	11th August 1911.	Do.
Do. . .	(382) Ma Thaw . .	Do. .	P. L. .	3,190	19th August 1911.	Do.
Do. . .	(383) Maung Po Thwin .	Do. .	P. L. .	3,146·25	31st August 1911.	Do.
Do. . .	(384) Chu Lu Yin . .	Do.	P. L. .	3,200	24th August 1911.	Do.

E. L = *Exploring License.* P. L.—*Prospecting License.* M. L.—*Mining Lease.*

BURMA—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Tavoy . .	(385) Quah Cheng Tock	All minerals (except oil).	P. L. .	603·25	23rd August 1911.	1 year.
Do. . .	(386) Chu Lu Yin . .	Do. .	P. L. .	2,087·20	19th August 1911.	Do.
Do. . .	(387) Maung Tun Mya .	Do. .	P. L. .	2,819·20	31st August 1911.	Do.
Do. . .	(388) Mr. C. W. Chater .	Do. .	P. L. .	3,200	21st July 1911.	Do.
Do. . .	(389) Messrs. Crisp & Co.	Do. .	P. L. .	3,200	Do. .	Do.
Do. . .	(390) Messrs. Mower & Co.	Do. .	P. L. (renewal).	1,280	8th July 1911.	Do.
Do. . .	(391) Messrs. Moolla Dawood Sons & Co.	Do. .	E. L. .	3,200	24th August 1911.	Do.
Do. . .	(392) Do. do. .	Do. .	E. L. .	3,200	Do. .	Do.
Do. . .	(393) Sulaiman Adamji .	Do. .	E. L. .	3,200	Do. .	Do.
Do. . .	(394) Do. do. .	Do. .	E. L. .	3,200	Do. .	Do.
Do. . .	(395) The Egani Tavoy Mining Co., Ltd.	Tin, wolfram, gold, and galena.	P. L. .	2,168·30	1st December 1911.	Do.
Do. . .	(396) Ong Hoe Kyin .	All minerals (except oil).	P. L. .	1,344·56	22nd December 1911.	Do.
Do. . .	(397) Tan Shwe Cho .	Do. .	P. L. .	1,713·92	31st October 1911.	Do.
Do. . .	(398) Maung Hpaw .	Do. .	P. L. .	2,995·28	24th November 1911.	Do.
Do. . .	(399) Do. do. .	Do. .	P. L. .	3,098·29	25th November 1911.	Do.
Do. . .	(400) Mr. A. R. Finlay .	Do. .	P. L. .	651·52	28th November 1911.	Do.
Do. . .	(401) Mr. C. Nash .	Do. .	P. L. .	3,120	8th November 1911.	Do.
Do. . .	(402) Mr. T. J. Mackay .	Do. .	P. L. .	3,190	28th November 1911.	Do.
Do. . .	(403) Messrs. Moolla Dawood Sons & Co.	Do. .	E. L. .	3,200	11th October 1911.	Do.
Do. . .	(404) C. Soo Don . .	Do. .	P. L. (renewal).	1,600	27th August 1911.	Do.
Do. . .	(405) Sulaiman Adamji .	Do. .	E. L. .	9,600	25th November 1911.	Do.
Do. . .	(406) Do. do. .	Do. .	E. L. .	3,200	Do.	Do.
Do. . .	(407) Tan Shwe Cho .	Do. .	P. L. (renewal).	2,604·8	5th November 1911.	Do.
Do. . .	(408) C. Soo Don . .	Do. .	P. L. (renewal).	2,600	4th December 1911.	Do.

E. L.=*Exploring License.* P. L.=*Prospecting License.* M. L.=*Mining Lease.*

BURMA—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Tavoy . .	(409) The Hitakaree & Co.	All minerals (except oil).	P. L. (renewal).	1,494·04	1st November 1911.	1 year.
Thaton . .	(410) Maung Sein Swe .	Metal bearing ores (except oil).	P. L. .	2,560	12th May 1911.	Do
Do. . .	(411) The Hon'ble Mr. Lim Chin Tsong.	Wolfram, gold, lead, silver, etc.	P. L. .	1,292·8	30th August 1911.	Do.
Do. . .	(412) Mr. M. M. Hla Oung and 2 others.	Wolfram and allied metals.	P. L. .	1,984	3rd August 1911.	Do.
Do. . .	(413) Ong Ba Wet .	Do. .	P. L. .	2,432	29th July 1911.	Do.
Do. . .	(414) Maung Thein San .	Do. .	P. L. .	1,952	22nd September 1911.	Do.
Do. . .	(415) Mr. S. Solaman .	Do. .	P. L. .	1,779·2	7th July 1911	Do.
Do. . .	(416) Maung Tun Yin .	Do. .	P. L. .	2,560	7th June 1911	Do.
Do. .	(417) U. Shwe Hlaw and 2 others.	Wolfram, gold, lead, silver, etc.	P. L. .	2,688	30th September 1911.	Do.
Do. . .	(418) Mr. M. M. Hla Oung and 2 others.	Do. .	P. L. .	1,459·2	30th August 1911.	Do.
Do. . .	(419) Maung Pan E .	Do. .	P. L. .	2,016	6th September 1911.	Do.
Do. .	(420) Maung Thein San .	Wolfram, gold, lead, etc.	P. L. .	2,073·6	12th September 1911.	Do.
Do. . .	(421) Messrs. Shwe Oh Brothers.	All minerals (except oil).	P. L. .	4,012·8	15th October 1911.	Do.
Do. . .	(422) Maung Sein Swe .	Do.	P. L. .	3,840	4th November 1911.	Do.
Do. . .	(423) Maung Po Tha .	Do. .	P. L. .	1,748·8	15th December 1911.	Do.
Do. .	(424) Yeo Eng Byan .	Do. .	P. L. .	13,926·4	22nd November 1911.	Do.
Do. . .	(425) Quah Cheng Guan	Do. .	P. L. .	6,912	20th November 1911.	Do.
Do. . .	(426) Ong Ba Wet .	Do. .	P. L. .	4,864	4th October 1911.	Do.
Do. . .	(427) Maung Shan Byu .	Do. .	P. L. .	9,120	28th November 1911.	Do.
Do. . .	(428) Maung Tun Yin	Do. .	P. L. .	3,200	19th October 1911.	Do.
Do. . .	(429) Do. do. .	Do. .	P. L. .	2,694·4	Do. .	Do.
Do. . .	(430) Maung Pu .	Do. .	P. L. .	2,432	17th October 1911.	Do.
Do. . .	(431) Mr. Lim Chin Tsong	Do. .	P. L. .	1,280	3rd October 1911.	Do.
Do. . .	(432) Ma Chein .	Do. .	P. L. .	2,790·4	28th November 1911.	Do.

E. L.=*Exploring License.* P. L.=*Prospecting License.* M. L.=*Mining Lease.*

BURMA—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Thaton . .	(433) Maung Pan E .	All minerals (except oil).	P. L. .	10·16	3rd November 1911.	1 year.
Thayetmyo .	(434) Ma Me . .	Minerals and petroleum.	E. L.	216,480	18th February 1911.	Do.
Do. .	(435) Maung Tun Aung Gyaw.	Do. .	E. L. .	15,520	7th February 1911.	Do.
Do. .	(436) Do. do. .	Do. .	E. L. .	9,600	Do. .	Do.
Do. .	(437) Maung Tun . .	Petroleum . .	E. L. .	18	8th February 1911.	Do.
Do. .	438) Messrs. Finlay, Fleming & Co, Agents for Burma Oil Co., Ltd.	Do. . .	P. L. . (renewal).	5,760	5th January 1911.	Do.
Do. .	(439) Shamuddin . .	Do. . .	P. L. .	2,880	18th May 1911.	Do.
Do. .	(440) Mr. E. H. Cunnigham Craig, Agent for Burma Oil Co, Ld.	Do. . .	P. L. .	4,480	30th May 1911.	Do.
Do. .	(441) Messrs. Finlay, Fleming & Co., Agent for Burma Oil Co., Ltd.	Do. . .	P. L. . (renewal).	960	10th May 1911.	Do
Do. .	(442) The Burma Oil Co, Ltd.	Do. . .	P. L. .	3,840	18th July 1911.	Do.
Do. .	(443) Shamuddin . .	Do. . .	P. L. . (renewal).	1,190 4	2nd June 1911.	Do.
Do. .	(444) Messrs Finlay, Fleming & Co., Agents for Burma Oil Co., Ltd.	Do. . .	P. L. . (renewal).	2,560	23rd October 1911.	Do.
Do. .	(445) Do. do. .	Do. .	P. L . (renewal).	3,200	23rd November 1911.	Do.
Do. .	(446) Do. do. .	Do. . .	P. L. . (renewal).	640	Do. .	Do.
Do. .	(447) Burma Oil Co. .	Do. . .	P. L. . (renewal).	640	30th August 1911.	Do.
Do. .	(448) Do. do. .	Do. . .	P. L. . (renewal).	1,440	29th August 1911.	Do.
Do.	(449) Indo-Burma Petroleum Co., Ltd.	Do. . .	P. L . (renewal).	1,280	15th July 1911.	Do.
Toungoo .	(450) Mr. F. H. Parry, Managing Agent, Dewalachi Galena Syndicate.	Galena . .	M. L. .	320	1st May 1909	30 years.
Do. .	(451) Messrs. Mower & Co.	Gold . .	P. L. .	1,465·60	3rd May 1911	1 year.
Do. .	(452) Maung Po Htu .	All kinds of metals	E. L. .	Toungoo Subdivision.	15th August 1911.	Do.
Do. .	(453) Maung Nyein .	Do. .	E. L. .	Pyu and Shwegyin Townships.	4th October 1911.	Do.

E. L.=*Exploring License.* P. L.=*Prospecting License.* M. L.=*Minin* [illegible]

BURMA—*concld.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Upper Chindwin.	(454) The Indo-Burma Petroleum Co., Ltd.	Petroleum . .	P. L. .	17,920	26th June 1911.	1 year.
Do. .	(455) Do. do. .	Do. . .	E. L. .	1,280,000	21st April 1911.	Do
Do. .	(456) Mr. J. W. Parry .	Minerals and mineral oil.	E. L. .	10,240	17th October 1911.	Do.
Do. .	(457) Do. do. .	Do. .	E. L. .	10,240	17th October 1911.	Do.
Do. .	(458) Mr. B. N. Burjorjee	All minerals .	P. L. .	32,000	16th November 1911.	Do.

CENTRAL PROVINCES.

Balaghat .	(459) Diwan Badadur Kasturchand Daga.	Manganese . .	M. L. .	12	1st February 1911.	30 years.
Do. .	(460) Mr. Byramji Pestonji.	Do. .	P. L. .	204	7th January 1911.	1 year.
Do. .	(461) Messrs. Schroder, Smidt & Co.	Do. . .	E. L. .	195	24th February 1911.	Do.
Do. .	(462) Do. do. .	Do. .	E. L.	108	Do. .	Not stated.
Do. .	(463) Lalla Ganesh Prasad and Janki Prasad.	Do. . .	P. L.	188	10th February 1911.	1 year.
Do. .	(464) Mr. Byramji Pestonji.	Do. . .	E. L. .	96	7th January 1911.	Do.
Do. .	(465) Indian Manganese Company.	Do. . .	P. L. .	596	23rd March 1911.	Do.
Do. .	(466) Mr. Byramji Pestonji.	Do. . .	P. L. .	332	7th January 1911.	Do.
Do. .	(467) Do. do. .	Do. . .	P. L. . (renewal).	81	10th December 1910.	Interim period during the expiry of the license and the execution of a mining lease.
Do. .	(468) Do. do. .	Do. .	P. L. .	56	19th December 1910.	Do.
Do. .	(469) Mr. M. B. Chopra .	Do. . .	P. L. . (renewal).	422	2nd February 1911.	6 months.
Do. .	(470) Babu Kripashankar	Do. . .	P. L. .	514	12th March 1911.	Do.
Do. .	(471) Rao Bahadur Narayan Rao Kelkar.	Do. . .	E. L. .	1,639	28th June 1911.	1 year

E. L. = *Exploring License.* P. L. = *Prospecting License.* M. L. = *Mining Lease.*

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Balaghat	(472) Messrs. Schroder, Smidt & Co.	Manganese	E. L.	456	10th April 1911.	1 year.
Do.	(473) Messrs. R. K. Chullaney & Sons.	Do.	P. L.	134	20th June 1911.	Do.
Do.	(474) Messrs. Schroder, Smidt & Co.	Do.	E. L.	160	6th April 1911	Do.
Do.	(475) Do. do.	Do.	P. L.	559	Do.	Do.
Do.	(476) Mr. Byramji Pestonji.	Do.	P. L.	136	2nd May 1911	Do.
Do.	(477) Do. do.	Do.	P. L.	96	9th April 1911	Do.
Do.	(478) Lala Ganesh Prasad Janki Prasad & Bros.	Do.	P. L.	338	6th July 1911	Do.
Do.	(479) Mr. Byramji Pestonji.	Do.	P. L. (renewal).	20	13th November 1910.	Till such time as will be required for execution of mining lease applied for.
Do.	(480) Diwan Bahadur Kasturchand Daga.	Do.	P. L.	39	14th June 1911.	1 year.
Do.	(481) Mr. E. C. Dungore	Do.	P. L. (renewal).	14	26th June 1911.	6 months.
Do.	(482) Rai Sahib Mathuraprasad and Motilal (Netra Manganese Co.)	Do.	M. L.	22	4th September 1911.	Will expire with the original lease, dated 18th August 1908.
Do	(483) Mr. R. K. Chullaney & Sons	Do.	P. L.	9	27th July 1911.	1 year.
Do.	(484) Mr. T. B. Kantharia.	Do.	M. L.	49	18th July 1911.	30 years.
Do.	(485) Rai Sahib Mathuraprasad and Motilal (Netra Manganese Co.).	Do.	M. L.	7	13th June 1911.	Do.
Do	(486) Mr. Byramji Pestonji.	Do	M. L.	6	2nd August 1911.	5 years.
Do.	(487) Central India Mining Co.	Do.	M. L.	169	1st September 1911.	26 years 1 month and 29 days.
Do	(488) Do. do.	Do.	M. L.	10	Do.	26 years 9 months and 5 days.

E. L.=*Exploring License.* P. L.=*Prospecting License.* M. L.=*Mining Lease.*

CENTRAL PROVINCES—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Balaghat .	(489) Seth Mahanandram Sheonarain.	Manganese .	P. L. .	59	27th July 1911.	1 year
Do. .	(490) Mr. E. C. Dungore	Do. . .	E. L. .	83	24th August 1911.	Do.
Do. .	(491) Indian Mineral Mining Syndicate.	Do. . .	E. L. .	746	30th September 1911.	Do.
Do. .	(492) Do. do. .	Do. . .	E. L. .	915	Do. .	Do.
Do.	(493) Seth Salikram .	Red Ochre . .	P. L. (renewal).	126	26th August 1911.	6 months.
Do. .	(494) Rao Sahib Hiralal Sukul.	Manganese . .	P. L. (renewal).	698	15th September 1911.	Do.
Do.	(495) Babu Kripa Shankar.	Do. . .	P. L. (renewal).	112	26th September 1911.	Do.
Do. .	(496) Messrs. Dutt, Burn & Co.	Manganese and iron.	M. L. .	259	12th October 1911.	30 years.
Do. .	(497) Lala Ganesh Prasad and Janki Prasad.	Manganese . .	M. L. .	70	7th November 1911.	Do.
Do. .	(498) Rai Sahib Mathuraprasad and Motilal (Netra Manganese Co.).	Do. . .	M. L. .	108	4th October 1911	Do.
Do. .	(499) Jubbulpore Prospecting Syndicate .	Do. . .	M. L. .	175	30th November 1911.	15 years.
Do. .	(500) Mr. M. B. Chopra .	Do. . .	P. L.	84	16th October 1911.	1 year.
Do. .	(501) Messrs. Schroder, Smidt & Co.	Do. . .	E. L. .	545	1st December 1911.	Do.
Do. .	(502) Messrs. Ganeshram Sheopratap & Sons.	Do. . .	P. L. .	16	16th October 1911.	Do.
Do. .	(503) Rai Sahib Hiralal Sukul.	Do. . .	P. L. .	80	Do. .	Do.
Do. .	(504) Hon'ble Mr. M. B. Dadabhoy.	Do. . .	P. L. .	568	1st December 1911.	Do.
Do. .	(505) Mr. Byramji Pestonji.	Do. . .	E. L. .	455	16th October 1911.	Do.
Do. .	(506) Do. do. .	Do. . .	P. L. (renewal)	19	24th October 1911.	Do.
Do.	(507) Do. do. .	Do. . .	P. L. (renewal).	2	Do. .	6 months.
Do.	(508) Mr. Rambilas Murlidhar.	Do. .	P. L. (renewal).	38	5th December 1911.	1 year.
Do. .	(509) Do. do. .	Do. . .	P. L. (renewal).	32	Do. .	Do.
Do. .	(510) Do. do. .	Do. . .	P. L. (renewal).	10	Do. .	Do.
Betul . .	(511) Mr. P. E. Cameron	Coal . . .	P. L. (renewal).	954	11th March 1911.	Do.

E. L. = *Exploring License.* P. L. = *Prospecting License.* M. L. = *Mining Lease*

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CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Betul . .	(512) Mr. P. E. Cameron	Coal . . .	P. L. (renewal).	8,107	1st April 1911.	1 year.
Do. . .	(513) Seth Lakhmichand	Graphite . .	P. L. (renewal).	91	4th January 1910.	Renewed up to 4th January 1912.
Bhandara .	(514) Messrs. Ramprasad and Lakshminarayan.	Manganese . .	P. L. .	880	25th January 1911.	1 year.
Do. .	(515) Mr. P. Balkrishna Naidu.	Do. . .	M. L. .	6	15th December 1910.	3 years.
Do. .	(516) Mr. Byramji Pestonji.	Do. . .	P. L. .	9	8th February 1911.	1 year.
Do. .	(517) Do. do. .	Do. . .	E. L. .	34	Do. .	Do.
Do. .	(518) Seth Gowardhandas.	Do. . .	P. L. .	39	5th February 1911.	Do.
Do. .	(519) Seth Motilal Sahukar.	Do. . .	P. L. .	200	29th March 1911.	Do.
Do. .	(520) Messrs. Brahmadatta and Baijnath.	Do. . .	P. L. .	193	22nd April 1911.	Do.
Do. .	(521) Do. do. .	Do. . .	P. L. .	106	26th May 1911.	Do.
Do. .	(522) Messrs. Schroder, Smidt & Co.	Do. . .	P. L. .	295	5th May 1911	Do.
Do. .	(523) Messrs. Brahmadatta and Baijnath	Do. . .	P. L. .	97	22nd April 1911.	Do.
Do. .	(524) Mr. Lakshman Damodar Lele.	Do. . .	P. L. .	83	Do. .	Do.
Do. .	(525) Messrs. Lalbihari and Ramcharan.	Do. . .	P. L. .	3	2nd May 1911	Do.
Do. .	(526) Seth Gawardhandas.	Do. . .	E. L. .	1,286	5th April 1911	Do.
Do. .	(527) Mr. P. Balkrishna Naidu.	Do. . .	P. L. .	163	18th September 1911.	Do.
Do. .	(528) Messrs. R. K. Chu'laney & Sons.	Asbestos . .	M. L. .	89	12th August 1911.	30 years.
Do. .	(529) Seth Gowardhandas.	Manganese . .	P. L. .	72	18th July 1911.	1 year.
Do. .	(530) Diwan Bahadur Kasturchand Daga.	Do. . .	P. L. .	9	26th July 1911.	Do.
Do. .	(531) Mr. Byramji Pestonji.	Do. . .	P. L. .	9	Do. .	Do.
Do. .	(532) Hon'ble Mr. M. B. Dadabhoy.	Do. . .	M. L. .	52	27th June 1911.	30 years.
Do. .	(533) Messrs. Kasambhoy, Gopaldas and Mahadeo Seth.	Do. . .	P. L. .	103	12th July 1911.	1 year.

E. L.=*Exploring License.* P. L.=*Prospecting License.* M. L.=*Mining Lease.*

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Bhandara .	(534) Messrs. Schroder, Smidt & Co.	Manganese .	P. L. .	194	16th August 1911.	1 year.
Do. .	(535) Mr. Byramji Pestonji.	Do. . .	E. L. .	998	26th July 1911.	Do.
Do. .	(536) Mr. Madhulal Dugar.	Do. . .	P. L. .	2	1st July 1911.	Do.
Do. .	(537) Mr. Ramprasad and Lakshminaram.	Do. . .	P. L. . (renewal).	446	22nd June 1911.	Do.
Do. .	(538) Mr. P. Balakrishna Naidu.	Do. . .	P. L. .	197	13th June 1911.	Do.
Do. .	(539) Mr. Byramji Pestonji.	Do. . .	P. L. .	10	18th September 1911.	Do.
Do. .	(540) Do. do. .	Do. . .	E. L. .	9	19th September 1911.	Do.
Do. . .	(541) Messrs. L. R. Ramchandra & Co.	Do. . .	P. L. . (renewal).	450	3rd August 1911.	6 months.
Do. .	(542) Mr. P. Balkrishna Naidu.	Do. . .	P. L. .	113	13th August 1911.	1 year.
Do. .	(543) Seth Motilal Bhairolal.	Do. . .	P. L. . (renewal).	6	22nd September 1911.	6 months.
Do. .	(544) Messrs. L. R. Ramchandra & Co.	Do. . .	P. L. . (renewal).	305	20th September 1911.	Do.
Do. .	(545) Sir Kasturchand Daga.	Do. . .	M. L. .	39	1st November 1911.	30 years.
Do. .	(546) Messrs. Lalbihari and Ramcharan.	Do. . .	M. L. .	200	30th November 1911.	Do.
Do. .	(547) Mr. Byramji Pestonji.	Do. . .	P. L. .	125	7th November 1911.	1 year.
Do. .	(548) Sir Kasturchand Daga.	Do. . .	P. L. .	77	4th November 1911.	Do.
Do. .	(549) Messrs. L. R. Ramchandra & Co.	Do. . .	P. L. .	24	16th October 1911.	Do.
Do. .	(550) Mr. Dhawakmal Ganpatlal.	Do. . .	E. L. .	11	Do. .	Do.
Do. .	(551) Messrs. Lalbihari and Ramcharan.	Do. . .	E. L. .	96	6th December 1911.	Do.
Bilaspur .	(552) Mr. E. Nagannah Naidu.	Red Ochre . .	P. L. .	41	4th March 1911.	Do.
Chhindwara .	(553) Rai Sahib Mathura Prasad & Co.	Manganese . .	M. L. .	96	23rd March 1911.	30 years.
Do. .	(554) Do. do. .	Do. .	M. L. .	29	Do. .	Do.
Do. .	(555) Mr. Byramji Pestonji.	Do. . .	P. L. .	172	6th January 1911.	1 year.
Do. .	(556) Messrs. Salpekar and Kartarbaksh and Seths Motilal and Lakshmichand.	Do. . .	P. L. .	255	23rd March 1911.	Do.

E. L.=*Exploring License.* P. L.=*Prospecting License.* M. L.=*Mining Lease*

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Chhindwara .	(557) Mr Byramji Pestonji.	All minerals .	E. L. .	59	6th January 1911.	1 year.
Do. .	(558) Do. do. .	Manganese . .	P L. .	59	21st February 1911.	Do.
Do. .	(559) Messrs. Gauri Dutt, Ganeshlal & Co.	Do .	E. L. .	379	27th March 1911.	Do.
Do. .	(560) Do. do.	Do. . .	P. L. .	379	9th May 1911	Do.
Do. .	(561) Hon'ble Mr. M. B. Dadabhoy.	Do. . .	P. L. .	448	9th June 1911	Do.
Do. .	(562) Do. do.	Do. .	P. L. .	94	3rd May 1911.	Do.
Do. .	(563) Do. do. .	Do. . .	P. L. .	20	Do. .	Do.
Do. .	(564) Do. do. .	Do. . .	E. L .	58	27th June 1911.	Do.
Do. .	(565) Do do .	Do. . .	P. L. .	258	15th April 1911.	Do.
Do. .	(566) Messrs Gauri Dutt, Ganeshlal and D'Costa.	Do. . .	E. L. .	650	19th May 1911.	Do.
Do. .	(567) Do. do .	Do. . .	P. L .	48	27th June 1911.	Do.
Do. .	(568) Hon'ble Mr. M. B. Dadabhoy.	Do. .	P. L. .	207	26th September 1911.	Do.
Do. .	(569) Mr. Bhopat Rao	Do. . .	P. L. .	230	4th August 1911.	Do.
Do. .	(570) Hon'ble Mr. M B. Dadabhoy.	Do. . .	P. L. .	159	27th July 1911.	Do.
Do. .	(571) Mr. Byramji Pestonji	All minerals .	E. L. .	4,120	21st July 1911.	Do.
Do. .	(572) Hon'ble Mr. M. B. Dadabhoy.	Manganese . .	P. L. .	271	27th July 1911.	Do.
Do. .	(573) Do. do. .	Do. .	P. L. .	115	Do. .	Do.
Do. .	(574) Do. do. .	Do. . .	P. L. .	373	Do. .	Do.
Do. .	(575) Do. do .	Do. . .	P. L. .	279	Do. .	Do.
Do. .	(576) Do. do. .	Do. . .	P. L. .	232	Do. .	Do.
Do.	(577) Messrs. Gauri Dutt, Ganeshlal and D'Costa.	Do. . .	P. L. .	73	15th July 1911.	Do.
Do. .	(578) Mr. Byramji Pestonji.	Do. . .	P. L. .	844	13th November 1911.	Do.
Do. .	(579) Central India Mining Co.	Do. . .	P. L. .	110	9th October 1911.	Do.
Do. .	(580) Do. do. .	Do. . .	P. L. .	146	Do. .	Do.
Do. .	(581) Do. do.	Do. . .	P. L .	115	Do. .	Do.

E. L.—*Exploring License.* P. L.—*Prospecting License.* M. L.—*Mining Lease.*

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Chhindwara .	(582) Hon'ble Mr. M. B. Dadabhoy.	Manganese . .	P. L. .	64	31st October 1911.	1 year.
Do. .	(583) Do. do. .	Do. . .	P. L. .	95	7th November 1911.	Do.
Jubbulpore .	(584) The Bombay Prospecting and Mining Syndicate.	Bauxite . .	M. L. .	420	9th November 1910.	30 years.
Do. .	(585) Messrs. H. F. Cook & Sons.	Do. . .	P. L. (renewal).	288	16th December 1910.	1 year.
Do. .	(586) Mr. M. Gupta, Bar-at-Law.	Steatite, soap-stone and talc.	P. L. .	216	20th September 1910.	Do.
Do. .	(587) Messrs. Byramji, Pestonji & Co.	Manganese . .	E. L. .	121	3rd April 1911	Do.
Do. .	(588) Do. do. .	Do. . .	E. L. .	52	Do. .	Do.
Do. . .	(589) Do. do. .	Red Ochre . .	E. L. .	66	23rd May 1911.	Do.
Do. .	(590) Do. do .	Copper . .	E. L. .	151	Do. .	Do.
Do. .	(591) Do. do. .	Yellow Ochre .	E. L. .	158	5th May 1911	Do.
Do. .	(592) Do. do. .	Red Ochre . .	E. L. .	17	23rd May 1911.	Do.
Do. .	(593) Mr. Byramji Pestonji.	Do. . .	E. L. .	3	28th July 1911.	Do.
Do. .	(594) Do. do. .	Manganese .	P. L. .	52	31st July 1911.	Do.
Do. .	(595) Mrs. D. H. D. Turner.	Copper, tin, silver and arsenic ore.	P. L .	168	30th September 1911.	Do.
Do. .	(596) Mr. P. C. Dutt .	Manganese and iron.	P. L. .	275	23rd August 1911.	Do.
Do. .	(597) Mr. T. B. Kantharia.	Manganese . .	P. L. .	234	28th July 1911.	Do.
Do. .	(598) The Bombay Prospecting and Mining Syndicate.	Steatite, soap-stone and talc.	P. L. .	848	21st April 1911.	Do.
Do. .	(599) Do. do. .	Do. .	P. L. .	179	28th February 1911.	Do.
Do. .	(600) Jubbulpore Prospecting Syndicate.	Copper, silver and gold.	M. L. .	70	17th November 1911.	30 years.
Do. .	(601) Mr. Byramji Pestonji.	Red Ochre . .	P. L. .	3	20th October 1911.	1 year.
Do. .	(602) Do. do. .	Manganese . .	P. L. .	121	Do.	Do.
Do. .	(603) Do. do. .	Red Ochre . .	P. L. .	69	17th November 1911.	Do.
Do. .	(604) Do. do. .	Pyrites of copper .	P. L. .	151	20th October 1911.	Do.
Do. .	(605) Do. do. .	Yellow Ochre .	P. L. .	158	Do. .	Do.

E. L.=*Exploring License.* P. L.=*Prospecting License.* M. L.=*Mining Lease.*

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Jubbulpore	(606) Mr. Byramji Pestonji.	Red Ochre	P. L.	17	17th November 1911.	1 year.
Do.	(607) Bombay Prospecting and Mining Syndicate.	Iron and bauxite	E. L.	4,923	5th November 1911.	Do.
Do.	(608) Mr. M. Gupta	Soap-stone	E. L.	70	26th October 1911.	Do.
Do	(609) Messrs. H. F. Cook & Sons.	Bauxite	P. L. (renewal).	288	16th December 1911.	Do.
Nagpur	(610) Mr. T. Cooverji Bhoja.	Manganese	M. L.	26	13th February 1911.	30 years.
Do.	(611) Indian Manganese Co.	Do.	M. L.	109	25th February 1911.	Do.
Do.	(612) Messrs. P. S. Kotwal and S. R. Naidu.	Do.	P. L.	250	19th January 1911.	1 year.
Do.	(613) Do. do.	Do.	P. L.	367	Do.	Do.
Do.	(614) Seth Motilal Sahukar.	Do.	P. L.	26	18th February 1911.	Do.
Do.	(615) Rai Sahib D. Lakshminarayan.	Do.	M. L.	63	17th January 1911.	3 years.
Do.	(616) C. P. Oriental Mining and Prospecting Syndicate.	Do.	M. L	39	3rd March 1911.	30 years.
Do.	(617) Do. do.	Do.	M. L.	142	16th March 1911.	Do.
Do.	(618) Nagpur Manganese Mining Syndicate.	Do.	M. L.	18	5th January 1911.	10 years.
Do.	(619) Messrs. Lalbihari Narayandas and Ramcharan Shankarlal.	Do.	P. L.	38	18th February 1911.	1 year.
Do.	(620) The Central India Mining Co.	Do.	M. L.	72	17th January 1911.	30 years.
Do.	(621) Mr. Lakshman Damodar Lele.	Do.	P. L.	108	7th January 1911.	1 year.
Do.	(622) Central Ind a Mining Co.	Do.	F. I.	1,660	4th January 1911.	Do.
Do.	(623) Do. do.	Do.	E. L.	3,172	Do.	Do.
Do.	(624) Mr. Byramji Pestonji.	Do.	P. L.	77	9th March 1911.	Do.
Do.	(625) Do. do.	Do.	P. L.	97	19th January 1911.	Do.
Do.	(626) Mr. Lakshman Damodar Lele.	Do.	P. L.	301	4th January 1911.	Do.
Do.	(627) Hon'ble Mr. G. M. Chitnavis	Do.	P. L.	130	1st February 1911.	Do.
Do.	(628) Hon'ble Mr. M. B. Dadabhoy.	Do.	P. L. (renewal).	37	17th December 1910.	6 months.

E. L.—*Exploring License.* P. L.—*Prospecting License.* M. L.—*Mining Lease.*

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nagpur	(629) Hon'ble Mr. M. B. Dadabhoy.	Manganese	P. L.	198	24th December 1910.	6 months.
Do.	(630) Mr. Lakshman Damodar Lele.	Do.	E. L.	19	19th January 1911.	1 year.
Do.	(631) Mr. A. Hanmant Rao.	Do.	E. L.	47	1st February 1911.	Do.
Do.	(632) Hon'ble Mr. M. B. Dadabhoy.	Do.	E. L.	63	23rd March 1911.	Do.
Do.	(633) Mr. Lakshman Damodar Lele.	Do.	E. L.	168	9th March 1911.	Do.
Do.	(634) Nagpur Manganese Mining Syndicate.	Do.	P. L (renewal).	190	11th December 1910	6 months.
Do.	(635) Do. do	Do.	P L.	355	15th June 1911.	1 year.
Do.	(636) Indian Manganese Co.	Do.	P. L.	101	20th June 1911.	Do.
Do.	(637) Messrs. Bahmansha Fouzdar Brothers.	Do	M L.	40	20th May 1911.	30 years.
Do.	(638) Mr. Hariram Sitaram Patel.	Do	P. L	356	9th May 1911	1 year.
Do	(639) Mr. P. Balkrishna Naidu.	Do.	P. L.	106	11th May 1911.	Do.
Do.	(640) Seth Motilal Sahukar.	Do.	P. L.	7	25th April 1911	Do.
Do.	(641) Messrs. Lalbihari Narayandas and Ramcharan Shankarlal.	Do.	P. L.	19	20th May 1911.	Do.
Do.	(642) Mr. T. B. Kantharia (Indian Mineral Mining Syndicate).	Do.	P L.	125	12th June 1911.	Do.
Do.	(643) Do. Do.	Do.	P. L.	67	Do.	Do.
Do.	(644) Messrs. Radhakishan Brothers.	Do.	P. L.	490	16th May 1911.	Do.
Do.	(645) Mr. P. Balkrishna Naidu.	Do.	P. L.	160	7th June 1911.	Do.
Do.	(646) Messrs. Bahmansha Fouzdar Brothers.	Do.	M. L.	131	20th May 1911.	30 years.
Do.	(647) Nagpur Manganese Mining Syndicate, Limited.	Do.	M. L.	37	27th March 1911.	5 years.
Do.	(648) Mr. T. B. Kantharia (Indian Mineral Mining Syndicate).	Do.	P. L.	257	12th June 1911.	1 year.
Do.	(649) Rai Bahadur Bansilal Abirchand, Mining Syndicate.	Do.	M. L.	13	12th May 1911.	30 years.

E. L.=*Exploring License.* P. L.=*Prospecting License.* M. L.=*Mining Lease.*

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nagpur	(650) Hon'ble Mr. M. B. Dadabhoy.	Manganese	M. L.	55	12th May 1911.	30 years.
Do.	(651) Do. do.	Do	M. L	128	Do.	Do.
Do.	(652) Mr. Lakshman Damodar Lele	Do	P. L	52	24th April 1911.	1 year.
Do.	(653) Messrs. Lalbihari Narayandas and Ramcharan Shankarlal.	Do.	E. L.	360	18th April 1911.	Do.
Do.	(654) Hon'ble Mr. M. B. Dadabhoy.	Do.	M. L.	25	12th May 1911.	30 years.
Do.	(655) Do. do.	Do.	P. L.	170	20th June 1911	1 year.
Do.	(656) Seth Madanandram Sheonarayan.	Do.	P. L.	316	19th May 1911	Till such time as will be required for execution of mining lease applied for.
Do.	(657) Diwan Bahadur Kasturchand Daga.	Do	P. L.	693	22nd May 1911.	1 year.
Do.	(658) Hon'ble Mr. M. B. Dadabhoy.	Do.	P. L.	234	20th June 1911.	Do
Do.	(659) Nagpur Manganese Mining Syndicate.	Do.	P. L. (renewal).	190	10th December 1910.	6 months.
Do.	(660) Central India Mining Company.	Do.	P. L.	256	15th June 1911.	1 year.
Do.	(661) Seth Motilal Sahukar.	Do	P. L.	108	15th June 1911.	Do.
Do.	(662) Messrs. Gauri Dutt, Ganeshlal and D'Costa.	Do	E. L.	308	19th May 1911.	Do.
Do.	(663) Mr. Lakshman Damodar Lele.	Do.	E. L.	119	19th April 1911.	Do.
Do.	(664) Nagpur Manganese Mining Syndicate.	Do.	P. L. (renewal).	66	15th April 1911.	3 months.
Do.	(665) Do. do.	Do.	P. L. (renewal).	93	Do.	Do.
Do.	(666) Messrs. Lalbihari Narayandas and Ramcharan Shankarlal.	Manganese and other minerals.	E. L.	128	20th May 1911.	1 year.
Do.	(667) Mr. Byramji Pestonji.	Do.	E. L.	324	9th May 1911.	Do.
Do.	(668) Nagpur Manganese Mining Syndicate.	Do.	E. L.	8	15th June 1911.	Do.
Do.	(669) Do. do.	Manganese	P. L. (renewal).	143	23rd May 1911.	Do.
Do.	(670) Do. do.	Do.	E. L.	52	19th May 1911.	Do.

E. L.=*Exploring License.* P. L.=*Prospecting License.* M. L.=*Mining Lease.*

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nagpur .	(671) Nagpur Manganese Mining Syndicate.	Manganese . .	P. L. (renewal).	25	23rd May 1911.	1 month.
Do. .	(672) Mr. Hanmant Rao	Do. . .	E. L. .	81	8th June 1911.	1 year.
Do. .	(673) Indian Mineral Mining Syndicate.	Do. . .	P. L. .	192	4th July 1911.	Do.
Do. .	(674) Indian Manganese Company.	Do. . .	M. L. .	138	27th June 1911.	30 years.
Do. .	(675) Mr. P. Balkrishna Naidu.	Do. . .	P. L. .	467	26th August 1911.	1 year.
Do. .	(676) Messrs. R. K. Chullaney and Sons.	Do. . .	P. L. .	235	4th July 1911.	Not stated.
Do. .	(677) Mr. Laxman Damodar Lele	Do. . .	P. L. .	265	27th September 1911.	1 year.
Do. .	(678) Messrs Lalbihari Narayandas and Ramcharan Shankarlal.	Do. . .	P. L. .	92	28th July 1911.	Do.
Do. .	(679) Mr. Shamji Madhoji	Do. . .	M. L. .	70	14th July 1911.	30 years.
Do. .	(680) Hon'ble Mr. G. M. Chitnavis	Do. . .	P. L. .	1,792	14th August 1911.	1 year.
Do. .	(681) Messrs. Lalbihari and Ramcharan	Do . .	P. L. .	65	28th July 1911.	Do.
Do. .	(682) Mr. T. B. Kantharia.	Do. . .	P. L. .	135	18th July 1911.	Do.
Do. .	(683) Do. do. .	Do. . .	P. L. .	59	Do. .	Do.
Do. .	(684) Central Provinces Oriental Mining Syndicate.	Do. . .	P. L. .	82	Do. .	Do.
Do. .	(685) Mr. Lakshman Damodar Lele.	Do. . .	P. L. .	89	27th September 1911.	Do
Do. .	(686) Nagpur Manganese Mining Syndicate.	Do. . .	M. L. .	1	6th September 1911.	10 years.
Do. .	(687) Mr. T. B. Kantharia.	Do. . .	P. L. .	70	18th July 1911.	1 year.
Do. .	(688) Mr. S. O. Holmes and Mr. Byramji Pestonji.	Wolframite .	P. L. (renewal).	46	7th January 1911	Interim period during the expiry of the license and the execution of a mining lease.
Do. .	(689) Mr. Govind Rao Baji Rao.	Manganese . .	P. L. .	284	26th August 1911.	1 year.
Do. .	(690) Central India Mining Company.	Do. . .	P. L. .	72	28th September 1911.	Do.

E. L. = *Exploring License.* P. L. = *Prospecting License.* M. L. = *Mining Lease.*

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nagpur .	(691) Hon'ble Mr. M. B. Dadabhoy.	Manganese . .	P. L. .	39	27th September 1911.	1 year.
Do. .	(692) Do. do. .	Do. . .	P. L. .	Not stated.	Do. .	Do.
Do. .	(693) Messrs. P. S. Kotwal and S. Rangah Naidu.	Do. . .	P. L. (renewal).	7	22nd May 1911.	Interim period during the expiry of the license and the execution of a mining lease.
Do. .	(694) Nagpur Manganese Mining Syndicate.	Do. . .	P. L. (renewal).	93	15th July 1911.	9 months.
Do. .	(695) Messrs. Radha Kishan Brothers.	Do. . .	P. L. .	7	4th July 1911.	1 year.
Do. .	(696) Nagpur Manganese Mining Syndicate.	Do. . .	P. L. (renewal).	34	23rd June 1911.	Interim period during the expiry of the license and execution of a mining lease.
Do. .	(697) Messrs. Radhakishan Brothers.	Do. . .	P. L. .	13	11th August 1911.	1 year.
Do. .	(698) Central Provinces Oriental Mining and Prospecting Syndicate.	Do. . .	P. L. .	2	27th September 1911.	Do.
Do. .	(699) Babu E. Nagannah Naidu.	Do. . .	P. L. (renewal).	16	6th September 1911.	6 months.
Do. .	(700) Nagpur Manganese Mining Syndicate.	Do. . .	E. L. .	112	16th September 1911.	1 year.
Do. .	(701) Mr. E. C. Dungore	Do. . .	P. L. .	228	20th December 1911	Do.
Do. .	(702) Hon'ble Mr. M. B. Dadabhoy.	Do. . .	M. L. .	92	18th October 1911	30 years
Do. .	(703) Mr. Hanmant Rao	Do. . .	P. L. .	163	4th November 1911.	1 year.
Do. .	(704) Hon'ble Mr. M. B. Dadabhoy.	Do. . .	P. L. .	121	14th November 1911.	Do
Do. .	(705) Do. do.	Do. . .	P. L. .	196	Do. .	Do.
Do. .	(706) Mr. Lakshman Damodar Lele.	Do. . .	P. L. .	138	13th December 1911.	Do
Do.	(707) Nagpur Manganese Mining Syndicate.	Do. .	P. L. .	71	4th November 1911.	Do.

E. L.=*Exploring License.* P. L.=*Prospecting License.* M. L.=*Mining Lease.*

CENTRAL PROVINCES—*concld.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nagpur.	(708) Mr. E. C. Dungore	Wolfram and copper.	P. L.	73	20th December 1911.	1 year.
Do.	(709) Central Provinces Oriental Mining and Prospecting Syndicate.	Manganese.	M. L.	38	24th November 1911.	30 years.
Do.	(710) Do. do.	Do.	M. L.	63	Do.	Do.
Do.	(711) Messrs. Lalbehari Narayandas and Ramcharan Shankarlal.	Do.	P. L.	30	27th October 1911.	1 year.
Do.	(712) Hon'ble Mr. M. B. Dadabhoy.	Do.	P. L.	122	14th November 1911.	Do.
Do.	(713) Nagpur Manganese Mining Syndicate.	Do.	P. L. (renewal).	454	23rd September 1911.	Do.
Do.	(714) Messrs. Lalbehari and Ramcharan.	Do.	P. L.	244	15th November 1911.	Do.
Do.	(715) Nagpur Manganese Mining Syndicate.	Do.	P. L.	86	25th October 1911.	Do.
Do.	(716) Mr. Laxman Damodar Lele.	Do.	E. L.	475	13th December 1911.	Do.
Raipur.	(717) Mr. R. K. Kanga.	Graphite	P. L. (renewal).	124	13th March 1909.	Renewed up to 29th February 1912.
Do.	(718) Mr. T. B. Kantharia.	Do.	P. L.	Entire village	14th October 1911.	1 year.
Do.	(719) Mr. Byramji Pestonji.	Graphite, antimony, copper, wolframite, lead and galena	P. L. (renewal).	555	24th October 1911.	Do.
Do.	(720) Mr. T. B. Kantharia.	Graphite	E. L.	Entire village	18th November 1911.	Do.
Saugor.	(721) Diwan Bahadur Ballabhdas.	Iron, coal, graphite, copper, silver, gold and mineral oil.	P. L.	95	6th January 1911.	Do.
Do.	(722) Rao Bahadur Damodar Rao Shrikhande.	Iron, copper, gold, silver, lead and sulphur.	P. L.	57	5th September 1911.	Do.
Seoni	(723) Mr. Byramji Pestonji.	Manganese.	P. L.	22	3rd May 1911	Do.
Do.	(724) Mr. Khimji Cuverji	Iron	P. L. (renewal).	1,609	18th December 1910.	6 months.
Do.	(725) Mr. Vallabhdas Dayal.	Mica	P. L.	2,917	25th November 1911.	1 year.
Do.	(726) Mr. Khimji Cuverji	Do.	P. L.	1,590	5th October 1911.	Do.
Do.	(727) Sir Kasturchand Daga.	Do.	P. L.	65	13th November 1911.	Do.

E. L. = *Exploring License.* P. L. = *Prospecting License.* M. L. = *Mining Lease.*

EASTERN BENGAL AND ASSAM.

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Cachar . .	(728) Mr. Priya Nath Sen	Oil . . .	P. L. .	1,600	5th April 1911.	1 year.
Chittagong .	(729) A. M. Berkeley, Chittagong.	Mineral oil . .	P. L. .	2,400	28th March 1911.	Do.
Do. .	(730) The Burma Oil Co., Ltd.	Oil . . .	P. L. (renewal).	3,667·2	15th April 1911.	Do.
Khasi and Jaintia Hills.	(731) Munshi Belayat Ali, Shillong.	Mineral oil . .	P. L. .	2,880	18th February 1911.	Do.
Do.	(732) Dr. R. A. Murphy .	Do. . .	P. L. .	25,600	10th November 1911.	Do.
Do.	(733) Do. do. .	Coal . . .	P. L. .	25,600	Do. .	Do.
Garo Hills .	(734) The Hon'ble Mr. R. H. Henderson, Cachar.	Do. . . .	P. L. .	128,000	31st March 1911.	Do.

MADRAS.

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Anantapur .	(735) The Indian Minerals Company, Betamcherla.	Steatite . .	P. L. .	107·34	31st August 1911.	1 year.
Chittoor .	(736) Govindji Odoji Sait	Corundum . .	P. L. .	387·74	29th September 1911.	Do.
Coimbatore .	(737) Do. do.	Do. . .	P. L. .	11·99	26th May 1911.	Do.
Do. .	(738) C. V. Narasiah .	Mica . . .	P. L. .	211·92	26th April 1911.	Do.
Cuddapah .	(739) Sir Henry King, Solicitor, Madras.	Galena . .	P. L. .	182·81	3rd March 1911.	Do.
Godavari .	(740) Mr. R. C. Dyrianatham, Proprietor, Messrs. Goodwill & Co., Madras.	Graphite . .	P. L. .	15	8th February 1911.	Do.
Do. .	(741) Fred. Cross, Esq., Madras.	Plumbago. .	P. L. .	1 280	Do.	Do.
Kurnool .	(742) Waljee Laljee Sait.	Diamond . .	M. L. .	4,526	12th April 1911.	30 years.
Do. .	(743) C. B. Oakley, Esq., Stafford House, Bangalore.	Do. . .	P. L. .	685·15	1st August 1911.	1 year.
Do .	(744) Mr. A. Ghose. Betamcherla.	All minerals .	E. L .	The whole of Dhone taluk.	22nd December 1911.	Do.
Malabar .	(745) Messrs. Gow & Co. (Pactolus Dredging Syndicate, Calcutta).	Gold . . .	M. L. .	Six rivers in Ernad taluk covering a length of about 82 miles.	1st December 1911.	30 years
Nellore . .	(746) P. Krishnaswami Mudaliyar.	All minerals .	E. L. .	Reserved and unoccupied Government lands in the taluks of Kavali, Rapur, Gudur and Atmakur.	20th January 1911.	1 year.

E. L.=Exploring License. P. L.=Prospecting License. M. L.=Mining Lease.

MADRAS—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nellore . .	(747) K. Audinarayana Reddi.	Mica	P. L. .	23·00	11th December 1910.	1 year.
Do. . .	(748) Indur Pattabhi Rami Reddi.	Do.	M. L. (renewal).	44·95	30th December 1910.	27 years.
Do. . .	(749) Lieut.-Col. M. E. Reporter.	Do.	P. L. .	21·30	12th May 1911.	1 year.
Do. . .	(750) P. Krishnaswami Mudaliyar.	Do.	P. L. .	10·31	16th April 1911.	Do.
Do. . .	(751) Mahommad Ziauddin Ahmed Sahib.	Do.	P. L. .	19·72	24th May 1911.	Do.
Do. . .	(752) Do. do. .	Do.	P. L. .	15·17	Do. .	Do.
Do. . .	(753) Muhammad Mara Abdul Rahiman Sahib.	Do.	M. L. .	3·4	30th June 1911.	20 years.
Do. . .	(754) P. Krishnaswami Mudaliyar.	Do.	P. L. .	11·13	17th September 1911.	1 year.
Do. . .	(755) A. Subramaniam Chettiar.	Do.	M. L. .	1·55	21st June 1911.	14 years 11 months and 5 days.
Do. . .	(756) Madras Mica Export Co.	Do.	P. L. (renewal).	58·03	17th July 1911.	1 year.
Do. . .	(757) Lieut.-Col. M. E. Reporter.	Do.	M. L. .	17·70	7th July 1911	20 years.
Do. . .	(758) A. Chennakesavalu Chetti.	All minerals	E. L. .	Not stated	30th September 1911.	1 year.
Do. . .	(759) Kota Sriramulu Chetti.	Mica	E. L. .	Dodlamitta mine and 20 acres around it.	14th October 1911.	Do.
Do. . .	(760) P. V. Krishna Rao	Do.	P. L.	13·25	7th September 1911.	Do.
Do. . .	(761) G. Nagayya . .	All minerals	E. L.	Not stated .	7th December 1911.	Do.
Salem . .	(762) Govindji Odoji Sait	Corundum . .	P. L. .	173·70	1st October 1911.	Do.
Do. . .	(763) Do do .	Do . . .	P. L. .	27·85	Do.	Do.
Tinnevelly .	(764) Messrs. W. A. Beardsell & Co., Madras.	Monazite . .	P. L. .	A strip of land extending to 20 miles of the sandy foreshore unoccupied above the low water mark to the east of the Nambiyar river.	23rd March 1911.	Do.

E. L.=*Exploring License.* P. L.=*Prospecting License.* M. L.=*Mining Lease.*

MADRAS—*concld.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Tinnevelly .	(765) The Morgan Crucible Co., Ltd., Trivandrum.	Plumbago . .	E. L. .	The whole of the Ambasamudram taluk including the reserved forest.	18th January 1911.	1 year.
Do. .	(766) Do. do. .	Do. . .	P. L. .	Survey No. 463 of Panakudi village.	23rd March 1911.	Do.
Do. .	(767) Do. do. .	Do. . .	P. L. .	32 cents in S. No. 305-2 of Vikramasingapuram and 40 acres in Siva Sylam reserved forest.	Do. .	Do.
Do. .	(768) James Short, Esq., Solicitor, Madras.	Garnet, monazite and other thorium compounds.	P. L. .	A strip of land extending to 20 miles of the sandy foreshore unoccupied above the low water mark to the west of the mouth of the Nambiyar river.	6th May 1911	Do.
Do.	(769) Govindji Odoji Sait	Corundum . .	M. L. .	2,173·47	20th September 1910.	10 years.
Vizagapatam .	(770) The Zamindar of Kottam, etc., Godavari.	Graphite and Copper.	P. L. .	50 80	19th January 1911.	1 year.

PUNJAB.

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Jhelum . .	(771) Lala Ishar Das of Pind Dadan Khan.	Coal	M. L. .	146	30th May 1909.	20 years.
Do. . .	(772) Do. do. .	Do.	P. L. . (first renewal).	100	11th April 1911.	1 year.
Do. . .	(773) Pandit Bhola Nath	Do.	P. L. . (second renewal).	55	20th July 1911.	Do.
Do. . .	(774) Lala Ishar Das	Do.	P. L. .	22·11	7th November 1911.	Do.

UNITED PROVINCES.

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Jhansi . .	(775) Messrs. Dina Nath and Barey Lal, Pleaders	Copper . .	M. L. .	5·35	1st October 1911.	30 years.

E. L.=*Exploring License.* P. L.=*Prospecting License.* M. L.=*Mining Lease.*

SUMMARY.

Provinces.	Prospecting Licenses.	Exploring Licenses.	Mining Leases.	Total of each Province.
Baluchistan	..	..	13	13
Bengal	16	..	15	31
Bombay	5	1	..	6
Burma	357	44	7	408
Central Provinces	181	48	40	269
Eastern Bengal and Assam	7	..	..	7
Madras	23	6	7	36
Punjab	3	..	1	4
United Provinces	..	..	1	1
Total for each kind and Grand Total, 1911	592	99	84	775
Totals for 1910	*401*	*102*	*132*	*635*

CLASSIFICATION OF LICENSES AND LEASES.

TABLE 26.—*Mining Leases granted in Baluchistan during 1911.*

DISTRICT.	1911.		
	No.	Area in acres.	Mineral.
Quetta	3	420	Coal.
Sibi	6	3,040	Do.
Zhob	4	320	Chromite.
TOTAL .	13	..	

TABLE 27.—*Prospecting Licenses and Mining Leases granted in Bengal during 1911.*

DISTRICT.	1911.		
	No.	Area in acres.	Mineral.
Prospecting Licenses.			
Hazaribagh	14	2,282·12	Mica.
Sambalpur	1	424·38	Coal.
Singhbhum	1	about 3,891·2	Chromite.
TOTAL .	16	..	
Mining Leases.			
Hazaribagh	14	2,904·5	Mica.
Sambalpur	1	49·14	Gold, silver and lead.
TOTAL .	15	..	

TABLE 28.—*Prospecting Licenses granted in Bombay during 1911.*

DISTRICT.	1911. No	1911. Area in acres.	1911. Mineral.
Dhárwár	2	111	Galena.
Panch Mahals	2	1,447	Manganese.
Ratnágiri	1	1,276	Manganese, iron and chromium.
TOTAL	5	..	

TABLE 29.—*Prospecting Licenses and Mining Leases granted in Burma during 1911.*

DISTRICT.	1911. No.	1911. Area in acres.	1911. Mineral.
Prospecting Licenses.			
Akyab	3	17,600	Petroleum.
Amherst	12	36,656	All minerals (except oil).
Do.	1	3,200	Lead, silver, copper, gold, etc.
Do.	1	3,200	Gold, silver, copper, tin, lead, etc.
Do.	1	309·14	Antimony.
Do.	1	3,200	Wolfram and allied minerals.
Bhamo	1	1,600	Gold.
Henzada	3	10,460	Petroleum.
Katha	1	220	Copper, gold, silver, lead, tin, iron, coal, asbestos and zinc.
Do.	1	2,560	Lead, copper and gold.
Do.	1	960	Lead and silver.
Do.	1	2,464	Lead.
Magwe	8	12,711·10	Petroleum.
Carried over	35	..	

TABLE 29. *—Prospecting Licenses and Mining Leases grant d in Burma during 1911*—contd.

DISTRICT.	1911. No.	1911. Area in acres.	1911. Mineral.
Prospecting Licenses—*contd*.			
Brought forward	35	..	
Mandalay	1	640	Gold, copper, galena, coal, wolfram antimony, aluminium and mica.
Do.	1	2,560	Lead and silver.
Do.	1	320	Galena, gold, silver and copper.
Do.	1	1,248·33	Gold, silver, lead, copper and mica.
Mergui	49	109,296·75	All minerals (except oil).
Do.	1	3,200	Iron pyrites.
Do.	1	3,200	Tin, wolfram, gold and silver.
Do.	1	2,764·80	Tin, gold, copper and wolfram.
Do.	1	3,200	Wolfram and allied minerals.
Do.	1	3,200	Wolfram, gold, tin and allied metals.
Do.	1	2,346·7	Coal.
Do.	1	2,316·80	Gold, tin, wolfram and allied metals.
Do.	1	2,135·04	Wolfram and iron.
Do.	1	302·08	Wolfram, tin and copper.
Minbu	20	37,505·97	Petroleum.
Myingyan	18	26,939·95	Do.
Northern Shan States	1	2,560	Copper and allied metals.
Ditto	1	3,200	Silver, lead, iron and copper.
Pakokku	20	16,709	Petroleum.
Pegu	1	5,670·4	Gold and tin.
Prome	10	14,117·27	Petroleum.
Ruby Mines	1	320	Metalliferous minerals.
Ditto	1	640	Copper, lead and iron ores.
Sagaing	1	231·73	Iron ore.
Salween	1	3,968	Asbestos.
Carried over	172	..	

TABLE 29.—*Prospecting Licenses and Mining Leases granted in Burma during 1911*—contd.

DISTRICT.	1911. No.	Area in acres.	Mineral.
Prospecting Licenses—*contd.*			
Brought forward	172	..	
Salween	1	3,200	Gold.
Do.	2	6,400	Wolfram.
Shwebo	4	11,520	Petroleum.
Southern Shan States	2	10,560	Coal.
Do.	1	3,120	Copper and allied minerals.
Do.	1	2,400	Gold, copper and other minerals.
Do.	6	13,640	All minerals (except mineral oil).
Do.	1	3,200	Gold, copper, tin and allied minerals.
Do.	1	1,120	Lead.
Do.	1	3,200	Copper.
Do.	1	3,200	Lead, copper and other minerals (except oil).
Do.	1	(A strip of land measuring 25 miles in an air line or to the limit of British territory whichever is nearer on either side of the Salween river).	Minerals and mineral oil.
Do.	1	400	Silver and lead.
Do.	1	3,200	Copper, lead, iron, antimony and associated minerals.
Do.	1	2,560	Tin, wolfram and associated minerals.
Do	1	960	Antimony and other ores.
Do.	1	3,200	Lead, copper and other minerals.
Carried over	199	..	

TABLE 29.—*Prospecting Licenses and Mining Leases granted in Burma during 1911*—concld.

DISTRICT.	1911. No.	1911. Area in acres.	1911. Mineral.
Prospecting Licenses—*concld.*			
Brought forward	199	..	
Tavoy	118	..	All minerals (except oil).
Do.	1	2,168·30	Tin, wolfram, gold and galena.
Thaton	1	2,560	Metal-bearing ores (except oil).
Do.	5	..	Wolfram, gold, lead, silver, etc.
Do.	5	..	Wolfram and allied metals.
Do.	13	..	All minerals (except oil).
Thayetmyo	12	..	Petroleum.
Toungoo	1	..	Gold.
Upper Chindwin	1	..	Petroleum.
Do.	1	..	All minerals.
TOTAL	357	..	
Mining Leases.			
Akyab	1	1,167	Coal.
Magwe	2	(2,560 and 164 State wells Yenangyaung)	Petroleum.
Myingyan	1	1,920	Do.
Pakokku	2	(1,280 and Blocks Nos. 119 and 121)	Do.
Toungoo	1	320	Galena.
TOTAL	7	..	

TABLE 30.—*Prospecting Licenses and Mining Leases granted in the Central Provinces during 1911.*

District.	1911. No.	1911. Area in acres.	1911. Mineral.
Prospecting Licenses.			
Balaghat	29	..	Manganese.
Do.	1	126	Red ochre.
Betul	2	..	Coal.
Do.	1	91	Graphite.
Bhandara	27	..	Manganese.
Bilaspur	1	41	Red ochre.
Chhindwara	24	..	Manganese.
Jubbulpore	2	..	Bauxite.
Do.	3	..	Steatite, soap-stone and talc.
Do.	3	..	Manganese.
Do.	1	168	Copper, tin, silver and arsenic ore.
Do.	1	275	Manganese and iron.
Do.	3	..	Red ochre.
Do.	1	151	Pyrites of copper.
Do.	1	158	Yellow ochre.
Nagpur	69	..	Manganese.
Do.	1	46	Wolframite.
Do.	1	..	Wolfram and copper.
Raipur	2	..	Graphite.
Do.	1	555	Graphite, antimony, copper, wolframite, lead and galena.
Saugor	1	95	Iron, coal, graphite, copper, silver, gold and mineral oil.
Do.	1	57	Iron, copper, gold, silver, lead and sulphur.
Seoni	1	122	Manganese.
Do.	1	1,609	Iron.
Do.	3	..	Mica.
TOTAL	181	..	

TABLE 30.—*Prospecting Licenses and Mining Leases granted in the Central Provinces during 1911*—concld.

District.	1911. No.	1911. Area in acres.	1911. Mineral.
Mining Leases.			
Balaghat	10	..	Manganese.
Do.	1	..	Manganese and iron.
Bhandara	4	..	Manganese.
Do.	1	..	Asbestos.
Chhindwara	2	..	Manganese.
Jubbulpore	1	..	Bauxite.
Do.	1	..	Copper, silver and gold.
Nagpur	20	..	Manganese.
TOTAL	40	..	

TABLE 31.—*Prospecting Licenses granted in Eastern Bengal and Assam during 1911.*

District.	1911. No.	1911. Area in acres.	1911. Mineral.
Cachar	1	1,600	Oil.
Chittagong	2	..	Mineral oil.
Khasi and Jaintia Hills	2	..	Do.
Do	1	..	Coal.
Garo Hills	1	..	Do.
TOTAL	7	..	

TABLE 32.—*Prospecting Licenses and Mining Leases granted in Madras during 1911.*

DISTRICT.	1911. No.	1911. Area in acres.	1911. Mineral.
Prospecting Licenses.			
Anantapur	1	107·34	Steatite.
Chittoor	1	387·74	Corundum.
Coimbatore	1	11·99	Ditto.
Do.	1	211·92	Mica.
Cuddapah	1	182·81	Galena.
Godavari	2	..	Graphite.
Kurnool	1	685·15	Diamond.
Nellore	8	..	Mica.
Salem	2	..	Corundum.
Tinnevelly	1	A strip of land extending to 20 miles of the sandy foreshore unoccupied above the low water mark to the east of the Nambiyar river.	Monazite.
Do.	2	Survey No. 463 of Panakudi village and 32 cents in S. No. 305-2 of Vikramasingapuram and 40 acres in Sivasylam reserved forest.	Plumbago.
Carried over	21	..	

THE SYSTEMATIC POSITION OF THE KODURITE SERIES, ESPECIALLY WITH REFERENCE TO THE QUANTITATIVE CLASSIFICATION. BY L. LEIGH FERMOR, D.SC., A.R.S.M., F.G.S., *Superintendent, Geological Survey of India.*

CONTENTS.

I.—INTRODUCTION.

SOME three years ago I published an account of a new series of rocks from the Vizagapatam district of Madras. The type rock is composed of orthoclase felspar, a manganese-garnet (spandite), and apatite, and is designated *kodurite* after the Kodur manganese-mine; kodurite is shown to be the basic member of a series of differentiated igneous rocks ranging in acidity from quartz-orthoclase rock, through intermediate quartz-kodurites and basic kodurites, to manganese-pyroxenites containing rhodonite and other manganese-pyroxenes[1]. The series derives its importance from the fact that it has, by secondary chemical alteration at the surface, given rise to a series of valuable manganese-ore deposits, the total output of which from 1892 to the end of 1911 is 1,168,751 tons.

This account, although in certain ways detailed, was really but an incident in a general account of the manganese-ore deposits of India; and, consequently, at the time, I was unable to investigate the classificatory position of this series of rocks.

[1] *Mem. Geol. Surv. Ind.*, XXXVII, "The Manganese-ore Deposits of India," pp. 243-279, (1909); name originally proposed in 1907, *Rec. G. S. I.*, XXXV, p. 22.

Recently, however, I have been able to examine this point, especially with reference to the "Quantitative Classification of Igneous Rocks", as set forth by Messrs. Cross, Iddings, Pirsson, and Washington, in their well-known work of the above title published in 1903.[1]

The ideal system of classification.

Prefacing this account of the Quantitative Classification, the book contains "An Introductory Review of the Development of Systematic Petrography in the Nineteenth Century," in which Mr. Whitman Cross gives an extremely valuable analysis of the various systems of rock classification—igneous, sedimentary, and metamorphic—hitherto proposed.

From this review one gathers that the chief faults of preceding schemes of classification lie in the want of "a logical and appropriate co-ordination and sequence of parts" (p. 88) and the "resort to the expedient of *appendices* to bring in rocks not otherwise provided for" (p. 91); and further that a satisfactory system of classification must not only find a logical position for all known rocks, but must be so devised as to be elastic and capable of logical extension to include any new types of rock.

The Quantitative System.

This review is, of course, the precursor to the detailed exposition of the new Quantitative Classification by the four joint authors in the second portion of the work quoted, and the reader enters eagerly upon its perusal buoyed up by the hope of a system logical, comprehensive, and elastic, in all its parts. He is compelled to recognise with admiration the ingenuity of the scheme, unfolded step by step, and providing a series of mathematically related compartments for the due reception both of all known igneous rocks and of all those to be discovered in the future. But his enthusiasm receives its first check when he learns the names (*e.g.*, quardofelic, pyrolic, sonnelic, with less uncouth terms, such as precalcic) applied to the compartments (class, order, rang, subrang, section of subrang, grad, section of grad, subgrad, section of subgrad, subsection of section, with further possibilities of expansion *ad infinitum*); it begins to wane as he realises the existence of 106 new adjectives, invented to characterise various chemical and mineral ratios; his enthusiasm sinks still further as he encounters the long list of newly-invented adjectives and prefixes (*e.g.*, alfersalphyric, grano-, grani-) to describe

[1] Also published in *Journal of Geology*, X, pp. 555-690, (1902).

the textures of rocks; and it drops almost to zero with the discovery that a piece of monzonite may be termed in the field a *biotitic hornblende-grano-dosalane*, or a *grano-hornblende-germanare*, whilst, after study with the microscope and in the laboratory, it may be called a *grano-hornblende-monzonase* or a *biotitic hornblende-grano-monzonose*, "according to what information we wished to convey" (p. 177).

The norm.

Nevertheless, one feature of the scheme stands brightly forth in the verbal gloom, namely, the idea of the *norm*, according to which any quantitative analysis of a rock may be converted into terms of certain *standard minerals*, thus attaching to each rock a standard or ideal mineral composition, and facilitating the comparison of various rocks, one with another, on the supposition that they had crystallised under certain ideal standard physical conditions.[1] For the mineral com position of a rock as it actually exists, the term *mode* is introduced. Whilst the norm and mode of a rock are frequently dissimilar, the mode of a rock may, and often does, coincide with its norm.

Before such a revolutionary scheme of classification can be accepted by the working petrographer, it is his duty to examine it on its merits, test it with actual examples, and compare the facility with which he is able to classify a given rock by this new method, and by any of the more normal schemes. Being personally attracted by the idea of the norm and the mode, and also by a method taking quantitative count of the mineral and chemical molecules, I was naturally disposed to give the new classification a fair trial, and for this purpose nothing seemed better than a new series of rocks of abnormal composition, such as the kodurite series; for thereby one could test one of Whitman Cross' chief desiderata for a satisfactory classification, namely, its elasticity and ability to dispense with appendices.

Result of investigation.

Before proceeding to investigate the classificatory position of the kodurite series by these methods, let me state at once the results. I find the new classification to lack in a measure the desired elasticity, but can propose a slight modification of the nomenclature by means of which this defect may be partly remedied; on the other hand, I find no difficulty in fitting this series of rocks into one of the more normal classifications, namely, that adopted by Hatch in his

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[1] Namely, such as would compel a magma on solidification to crystallise out with the mineral composition of the norm.

admirable "Text-book of Petrology", 5th edition, 1909, and originally unfolded in a paper entitled "The Classification of the Plutonic Rocks" in *Science Progress*, III, pp. 244-264, (1908).

II.—THE KODURITE SERIES.

A.—The Quantitative Classification of Kodurite and Garnet-rock.

For the purpose of this investigation I have taken the two calculated analyses of kodurite from Kotakarra and Boirani, respectively, as given on page 261 of *Mem. G. S. I.*, XXXVII; and to prevent any misconceptions, let me state at once that the Kotakarra rock represents the typical development of the kodurite series as met with in the Vizagapatam district, whilst the rock from Boirani in the Ganjam district, although designated *kodurite*, differs considerably in one respect from the typical rock. Each variety consists essentially of orthoclase, garnet, and apatite; but whereas the typical rock of Kotakarra contains a highly manganesian garnet (16·50% of MnO), which I have designated spandite (indicating its intermediate position between *sp*essartite and *and*rad*ite*), the garnet (grandite) in the Boirani rock contains a relatively small amount of manganese (2·68% MnO) and lies between *gr*ossularite and *and*rad*ite* in composition. It is convenient at present to extend the term *kodurite* to the Boirani rock, but subsequent more detailed examination in the field and laboratory may indicate the desirability of using a separate name for the rock.

In both Vizagapatam and Ganjam, ultra-basic modifications of the series exist, comprised entirely of the garnet of the kodurite with a variable amount of apatite (sometimes scarce and sometimes abundant).[1] As apatite appears as apatite in both the norm and the mode of a rock, I am assuming two garnet-rocks of the composition respectively of the Kotakarra and Boirani garnets given on page 258. Any desired percentage of apatite could be introduced into the rock without affecting the relative amounts of the other minerals composing the norms of the garnet-rocks.

Analyses.

The calculations have been made in accordance with the principles laid down in the American work already cited, and I will tabulate the results below.

[1] There are also the ultra-basic pyroxenites, but I am not considering these at present.

The analyses taken for calculation are as follows:—

	Kotakarra kodurite.	Boirani kodurite.	Kotakarra garnet-rock.	Boirani garnet-rock.
SiO_2	47·45	53·36	37·57	38·18
TiO_2	0·29	0·24	..	..
Al_2O_3	18·00	16·31	18·98	14·22
Fe_2O_3	1·91	4·17	3·47	11·41
FeO	4·10	0·79	7·45	2·16
MnO	9·08	0·98	16·50	2·68
MgO	0·13	0·22	0·23	0·65
CaO	10·37	12·54	15·80	30·70
K_2O	6·97	9·75	..	..
Na_2O	..	0·33	..	..
P_2O_5	1·42	1·11	..	..
CaF_2	0·26	0·20	..	..
CuO	0·02	..	..	..
TOTAL .	100·00	100·00	100·00	100·00
G. .	3·23	2·92	4·02	3·76

The norms.

A glance at these analyses shows that the rocks are of unusual composition in one particular, namely the persistent presence of a relatively high amount of MnO—varying from 0·98 to 16·50 per cent. As the amount of manganese protoxide in an igneous rock is usually insignificant, the method followed in the book cited is to unite small amounts of MnO with FeO, and also BaO and SrO with CaO, and Cr_2O_3 with Fe_2O_3, "unless these unusual components occur in sufficient amounts to make their calculation as special mineral molecules desirable" (p. 188). In the present instance it is obviously desirable to treat the MnO as entering into special mineral molecules. Relatively small amounts of MnO, as in the Boirani kodurite, could

be taken into the diopside or hedenburgite molecule, but this is not possible with larger amounts, as there is no known mineral of the composition $CaO.MnO.2SiO_2$, corresponding to the complete replacement by MnO of the MgO in diopside or of the FeO in hedenbergite. Consequently it is necessary to introduce new two norm minerals, namely, the metasilicate rhodonite, $MnSiO_3$, and the orthosilicate tephroite, Mn_2SiO_4. With this modification, the following norms have been calculated from the foregoing analyses :—

Mineral.	Formula.	Kotakarra kodurite.	Boirani kodurite.	Kotakarra garnet-rock.	Boirani garnet-rock.
Orthoclase .	$K_2O.Al_2O_3.6SiO_2$.	35·47	55·60	..	..
Leucite .	$K_2O.Al_2O_3.4SiO_2$.	4·53	1·61	..	..
Nephelite . .	$Na_2O.Al_2O_3.2SiO_2$.	..	1·50	..	..
Anorthite .	$CaO.Al_2O_3.2SiO_2$.	28·44	14·15	51·74	38·75
Diopside .	$CaO.MgO.2SiO_2$.	..	1·19	..	3·50
Hedenbergite .	$CaO.FeO.2SiO_2$.	11·02	..	7·25	..
Wollastonite .	$CaO.SiO_2$ . .	0·93	16·71	..	5·49
Akermanite .	$4CaO.3SiO_2$.	..	..	6·71	34·87
Fayalite . .	$2FeO.SiO_2$.	..	..	5·80	..
Tephroite . .	$2MnO.SiO_2$ . .	12·93	1·39	23·47	3·80
Magnetite .	$FeO.Fe_2O_3$ . .	2·76	1·86	5·03	6·96
Hematite .	Fe_2O_3 . .	..	2·89	..	6·61
Ilmenite .	$FeO.TiO_2$ . .	0·55	0·46	..	..
Apatite . .	$3(3CaO.P_2O_5)+CaF_2$	3·33	2·62	..	..
		99·96	99·98	100·00	99·98

The process and results of classification.

We now have the material to classify these four rocks according to the quantitative method, making use of the various mineral and oxide ratios, as explained on pages 128-144 of the work cited.

According to this method, the position of the first rock may be analysed in detail as follows :—

$\frac{\text{Sal.}}{\text{Fem.}} = \frac{68 \cdot 44}{31 \cdot 52} < \frac{7}{1} > \frac{5}{3}$ . . . ∴ Class II—Dosalane—dosalic.

$\frac{L}{F} = \frac{4 \cdot 53}{13 \cdot 91} < \frac{1}{7}$ . . . . . ∴ Order 5—Germanare—perfelic.

$\frac{K_2O' + Na_2O'}{CaO'} = \frac{742}{1023} < \frac{5}{3} > \frac{3}{5}$. ∴ Rang 3—Andase—alkalicalcic.

$\frac{K_2O'}{Na_2O'} > \frac{7}{1}$ . . . . . . ∴ Subrang 1—Perpotassic.

$\frac{P+O}{M} = \frac{24 \cdot 88}{3 \cdot 31} < \frac{7}{1} > \frac{5}{3}$ . . . ∴ Grad 1—Propolic.

$\frac{(Mg, Fe, Mn)\,O + CaO''}{K_2O'' + Na_2O''} > \frac{5}{3}$ . . . ∴ Subgrad 1—Premirlic.

$\frac{(Mg, Mn, Fe)O}{CaO''} = \frac{1725}{829} > \frac{5}{3}$ . . ∴ Section of subgrad 1—Premiric.

$\frac{MgO}{(Fe, Mn)O} = \frac{32}{1693} < \frac{3}{5}$ . . . ∴ Subsection 3 of section 1—Premanganoferrous.

$\frac{FeO}{MnO} = \frac{414}{1279} < \frac{3}{5}$ . . . . ∴ Section 3 of subsection 3 of section 1—Premanganous.

The position of each of these rocks in each of the steps of the quantitative ladder is indicated in the following table :—

	I. Kodurite of Kotakarra.			II. Kodurite of Boirani.			III. Garnet-rock of Kotakarra.			IV. Garnet-rock of Boirani.		
	No.	Name.	Character.	No.	Name.	Character.	No.	Name.	Character.	No.	Name.	Character.
Class	II	Dosalane	Dosalic	II	Dosalane	Dosalic	III	Salfemane.	Salfemic	III	Salfemane.	Salfemic.
Sub-class	1	..	..	1	..	..	1	..	..	1	..	..
Order	5	Germanare	Perfelic	5	Germanare	Perfelic	5	Gallare	Perfelic	5	Gallare	Perfelic.
Rang	3	Andase	Alkalicalcic	2	Monzonase.	Domalkalic	5	Kedabekase	Percalcic	5	Kedabekase	Percalcic.
Subrang	1	Kodurose	Perpotassic	1	Boiranose.	Perpotassic	*	Kedabekose in all subrangs.		*	Kedabekose in all subrangs.	
Grad	1	Kodurate	Prepolic	1	Boiranate	Prepolic	1	Spandate	Perpolic	2	Grandate	Dopolic.
Section	..	..	..	..	..	..	3	Spandiate.	Preolic	..	Grandiate	Preolic.
Subgrad	1	Kodurote	Premirlic	1	Boiranote	Premirlic	1	Spandote	Permirlic	1	Grandote	Permirlic.
Section of subgrad.	1	..	Premiric	13	..	Precalcic	1	..	Premiric	3	..	Precalcic.
Subsection of section.	3	..	Premanganoferrous.	3	..	Premanganoferrous.	3	..	Premanganoferrous.	3	..	Premanganoferrous.
Section of subsection.	3	..	Premanganous.	2	..	Manganoferrous.	3	..	Premanganous.	2	..	Manganoferrous.

*The subrang depends on the ratio of K_2O' to Na_2O', but as these are both absent in rocks III and IV, it is not possible to assign these two rocks to subrangs.

From the above table it will be seen that both kodurites fall into class II—the *Salfemanes:* all four rocks fall into order five of their respective classes, the kodurites belonging to the order *germanare* and the garnet-rocks to the order *gallare*. Passing now to rangs, we see that whilst the two garnet-rocks fall into one rang—*kedabekase*—, the kodurites fall into two separate rangs, *andase* and *monzonase*. Arriving at the subrangs, it is necessary to apply to the garnet-rocks, owing to the absence of alkalies, the name of the rang with the necessary terminal modification, namely *kedabekose*. According to the tables given in the Quantitative Classification, no names had then (1903) been proposed for the two subrangs into which the two kodurites fall. These tables are repeated in Iddings' "Rock Minerals," Vol. I, (1909), and on page 427, I find that these two subrangs were then still unoccupied. On the assumption that they have not yet been filled and that the authors of the classification have the natural desire to find representatives of all their rangs and subrangs as soon as possible, I offer them the terms *kodurose* and *boiranose;* from these follow the terms *kodurate, boiranate, kodurote* and *boiranote*, for the respective grads and subgrads. Returning now to the two garnet-rocks, since the absence of alkalies prevents one assigning them to subrangs, it is necessary to propose terms to describe the grads to which they belong. The characteristic garnets of the Kotakarra and Boirani kodurites have been termed by me spandite and grandite respectively, and therefore I suggest the following names for the respective grads, sections of grads, and subgrads: *spandate, spandiate, spandote,* and *grandate, grandiate, grandote.*

With a system so artificial as the one under discussion, which is the product of the imagination of its authors rather than a natural growth from any previous system, it seems to me desirable for the authors to act as a supreme court of appeal, and to accept or reject any new names that may be proposed. Therefore I offer all the above terms for acceptance or rejection by the joint authors of the system. And if I may offer a suggestion, it is this, that the authors, if they wish this system to stand the maximum chance of adoption, should, at regular intervals, say once a year, publish in the same periodical, such as the *Journal of Geology*, the tables of classes, orders, rangs, and subrangs, given in their Quantitative Classification, brought up to date and showing all the names for orders, rangs and subrangs that have been accepted.

I must now direct the reader's attention to the foregoing table. He will notice that, in conformity with the principles of this classification, I have proposed names for two subrangs, four grads, two sections of grads, and four subgrads. Let us assume them as adopted. Then we have one subrang, labelled kodurose, occupied by a rock containing in its norm 12·93 per cent. of tephroite, the manganese-olivine, whilst the features that have thrown the Kotakarra kodurite into this particular subrang are in order :—

(1) its ratio of salic to femic minerals,

(2) its ratio of felspathoids to felspars,

(3) its ratio of alkalies to lime,

(4) its ratio of potash to soda,

ratios 2, 3 and 4 referring solely to the salic minerals. It is obvious, therefore, that other rocks may be discovered in the future which, when the above-mentioned tests are applied, will also fall into the kodurose subrang, although they may be practically devoid of manganese, which is present to the amount of 9·08 per cent. of MnO in the type rock. This seems to indicate at once a serious flaw in the system. Further, the effect of the presence of manganese does not make itself felt until the ninth sub-division is reached, the criteria on the way down being in turn :

(5) the ratio of pyroxenes + olivines to magnetite, etc.

(6) the ratio of MgO + FeO (with MnO) + CaO in the femic minerals to the alkalies of the femic minerals.

(7) ratio of MgO + FeO (with MnO) to the CaO in the femic minerals.

(8) ratio of MgO to FeO (with MnO).

(9) ratio of FeO to MnO, introduced by myself.

There certainly seems to be something lacking in a system which takes no effective account, until the ninth sub-division of the system is reached, of a constituent that is fourth in order of importance in the chemical analysis and third in order of importance in the norm.

The same criticisms apply to boiranose, but to a much smaller degree on account of the much smaller amount of MnO present; but they apply in an even more striking manner to the Kotakarra garnet-rock (spandite-rock), in which MnO is third in order of importance in the chemical analysis, and tephroite, Mn_2SiO_4, is second in order of importance in the norm, of which it forms nearly 25 per cent.

The inability of the system to deal with high MnO.

It is interesting also to enquire why the Kotakarra and Boirani kodurites have fallen into the two different rangs, andase and monzonase. The answer points to another flaw in the methods of this system. The chief difference between the two kodurites lies in the composition of the respective garnets, and, as will be seen from a reference to the analyses on page 212, the essential difference between the two garnets is that the place of most of the MnO of the Kotakarra garnet is taken by CaO in the Boirani garnet.[1] The Kotakarra rock has 9·08 per cent. of MnO and the Boirani one only 0·98 per cent. of MnO. It is not this feature, however, that has thrown these two rocks into different rangs, but the fact that the Kotakarra rock contains only 6·97 per cent. of K_2O compared with 9·75 per cent. of K_2O + 0·33 per cent. of Na_2O = 10·08 per cent. of alkalies in the Boirani rock; so that the ratio of alkalies to lime in the Kotakarra rock is $< 5/3 > 3/5$, making it alkalicalic or andase, whilst the ratio in the Boirani rock is $< 7/1 > 5/3$, making it domalkalic or monzonase.

However, one cannot tamper with the fundamental features of a classification, and hence these two rocks must be assigned to different rangs on account of what I regard as a comparatively trivial difference; whilst the more important difference, namely, in the amounts of MnO, is of no account, although it is such as to make one hesitate to extend to the Boirani rock the name kodurite, which belongs primarily to the manganese-bearing rocks of the Vizagapatam district.

As the system is so constructed that my kodurite (with 9·08 per cent. MnO) and a rock of similar composition, but with the manganese replaced by iron, would fall into the same rang, it is

[1] There is also a difference in the state of oxidation of a portion of the iron, but this does not affect nomenclature till one reaches the grads.

obvious that in a measure the quantitative system has failed, in one particular instance, to exhibit the elasticity that Mr. Whitman Cross regards as necessary to any satisfactory classification.

Inability to deal with high CaO, BaO, & NiO.

If an unusually large amount of MnO in a rock can affect the classification so adversely, one wonders if there are any other constituents, which, if present in unexpectedly large amount, might have the same effect. From a consideration of the principles on which the norm is formed and the use subsequently made of the norm minerals, one sees at once that SrO, BaO, and NiO, would, any of them, if present in an igneous rock in quantity, upset the system in a similar way to MnO. As in the case of MnO, the authors have provided that, in calculating the norm, SrO and BaO are to be regarded as CaO, and NiO as FeO, "unless these unusual components occur in sufficient amounts to make their calculation as special mineral molecules desirable.'' But, as in the case of MnO, there is apparently no provision in the scheme of classification for unusual norm minerals of this nature; and consequently, in carrying out the evolutions necessary for ascertaining the appropriate compartments of the scheme for a rock containing an unusual amount of strontium, for example, it would be necessary to regard the SrO, as CaO. It is easy to see that in this way one might obtain another member of the kodurose subrang, completely devoid of MnO, but containing a considerable percentage of SrO, whilst we should be unable to take any account of the SrO before reaching sections or subsections of subgrads.

Suggested method of overcoming the difficulty.

It seems to me that the quantitative system almost reduces itself to an absurdity when it is required to receive rocks containing large amount of such constituents as MnO or SrO. There is, however, one possible method of escape from the nomenclature difficulty. If, for instance, one could find a rock in the kodurose subrang free from MnO, the subrang should be named after this manganese-free rock—let us suggest *vizagapatamose* after the district from which kodurite comes. Kodurite might then be termed *mangan-vizagapatamose*, whilst a strontium member of the same subrang would be a *strontio-vizagapatamose* and a barium member would be *baryto-vizagapatamose*. Similarly the rangs might be termed

mangan-andase, *strontio-andase*, etc. It seems difficult to suggest any other escape, but the necessity of following such a path seems to me to disturb the rounded symmetry of the system. It would be equivalent to accepting appendices, which, according to Mr. Cross, should not be necessary in any satisfactory classification.[1]

B—Treatment of the Kodurite Series in Hatch's Classification.

Having attempted to fit these Indian rocks into the Quantitative Classification, and having failed, except by an expedient unsanctioned by the propounders of the scheme and opposed to its spirit, it will now be interesting to see whether any such difficulties arise in the ordinary methods of classification.

It must be conceded that the ordinary method of classifying igneous rocks into three groups—plutonic, hypabyssal, and volcanic—based on their mode of eruption and correlated texture; subdividing each of these groups into four sections—acid, intermediate, basic, and ultrabasic—based on the silica percentage; and arranging the rocks under each heading thus obtained in accordance with their mineralogical peculiarities, is frequently unsatisfactory, and becomes more unsatisfactory year by year with the discovery of numerous fresh types.

In 1908 Dr. F. H. Hatch, in the paper already cited, put forward a classification of the plutonic rocks that includes many of the features of the older systems, and at the same time, influenced by the Quantitative Classification of our American friends, gives greater weight to quantitative chemical considerations than was formerly the case. As in the earlier classifications, the plutonic rocks are divided into three horizontal series—acid, intermediate, and basic—according to their silica percentage; but instead of grouping all

[1] One further method of escape suggests itself, *viz.*, to break up orders in classes II and III into suborders based on the ratios of MnO to FeO. Once this was done, however, it would not be possible to deal with rocks rich in strontium or barium by forming suborders according to the ratios of SrO to CaO, or of BaO to CaO. Further, this would be introducing distinctions into suborders on a chemical basis, whereas that already adopted for suborders to classes IV and V is on a mineral basis (*l.c.*, p. 134). In addition it would be making use of char-

the acid rocks into one heterogeneous compartment, and similarly the intermediate and basic rocks, Hatch arranges the rocks in five vertical series according to the felspars and felspathoids, as can be seen from the following table, the basis of the vertical series being the relative proportions of calc-alkali felspars (oligoclase to anorthite) to the alkali felspars (orthoclase, albite and microcline), and the

	ALKALI SERIES.				
	Felspathoid Series.	Soda Series.	Potash Series.	Monzonite Series.	Calc-alkali Series.
Acid group $> 66\% SiO_2$	..	Soda-granite.	Potash-granite.	Adamellite	Granodiorite.
Intermediate $52-66\% SiO_2$	Nepheline-syenite.	Soda-syenite.	Potash-syenite.	Monzonite	Diorite
Basic group $< 52\% SiO_2$	Nepheline-gabbro.	Essexite .	Shonkinite	Kentallenite.	Gabbro
		CA $<$ $\frac{1}{3}$ A $>$ $\frac{2}{3}$	CA $<$ $\frac{1}{3}$ A $>$ $\frac{2}{3}$	CA $=$ $\frac{1}{3}$ to $\frac{2}{3}$ A $=$ $\frac{2}{3}$ to $\frac{1}{3}$	CA $>$ $\frac{2}{3}$ A $<$ $\frac{1}{3}$

CA = proportion of calc-alkali felspar in total felspars.
A = " " alkali " " " "

presence or absence of felspathoids, as is indicated at the base of the table, the limits of the monzonite series being fixed in accordance with proportions originally suggested by Lindgren. Each of these compartments holds a family or sub-family, the internal arrangements of which may be conducted on a mineralogical basis. This series enables one quickly to refer any given plutonic rock to its sub-family, once the silica percentage is determined and the relative amounts of alkali and calc-alkali felspars are known, which may be ascertained either chemically or optically. Moreover, when a rock reaches a given compartment, it finds there companions

acteristics of the femic minerals in these two classes at a point where only the salic minerals should be considered. The same reason prevents one from treating the MnO at any earlier stage than the grads, as it is not till the grads are reached in classes I to III that the femic minerals are considered at all, except in the primal division into classes. The consequence is that the MnO cannot be considered at an earlier point than is done by me in the table on page 215.

that seem better sorted than those one finds in even such a small sub-division as a subrang.[1]

Position of kodurite series.

Following Hatch's method, the position of the Kotakarra kodurite is seen instantly. It is basic, because it contains less than 52 per cent. of SiO_2. It belongs to the potash series. Therefore it falls into the shonkinite family. It contains an abnormal amount of manganese, and therefore may be designated a *mangan-shonkinite*. It shows, however, an abnormal mode in containing garnet as its femic mineral instead of pyroxenes and olivines. Therefore it is better not to use the term *shonkinite*, but to use the special name chosen for it, *viz.*, *kodurite*.

The complete list of members of the kodurite series as given on page 250 of *Mem., Geol. Sur. Ind.*, XXXVII, is repeated in the right-hand column of the following table, whilst in the middle column are placed the names of the three main sub-divisions of the potash series in Hatch's classification.

——	Potash Series.	Kodurite Series.
Acid	Potash-granite .	Quartz-orthoclase rock. Apatite-quartz-orthoclase-rock. Quartz-kodurite in part.
Intermediate . . .	Potash-syenite .	Quartz-kodurite in part. Orthoclase-rock
Basic	Shonkinite . .	Kodurite. Pyroxene-kodurite. Biotite-kodurite.
Ultra-basic . . .	....	Spandite-rock. Apatite-spandite-rock. Pyroxene-spandite-rock. Manganese-pyroxenites. Graphitic manganese-pyroxenites.

[1] Evans, in discussing the Quantitative Classification (*Science Progress*, I, pp. 259-280, 1906), points out that one subrang, andose, contains rocks as different as tonalite and gabbro, whilst toscanose includes granites, syenites, and diorites, not to speak of hemi-crystalline and glassy representatives; and a subrang is such a relatively small sub-division that there are 402 of them, with possibilities of many others, indicated in the tables facing p. 166 of the work cited.

The case of the ultra-basic rocks calls for some comment. Hatch does not include the ultra-basic rocks—picrite, perknite, and peridotite families—with the plutonic rocks with which they are often associated, because they are hypabyssal in their mode of occurrence, occurring either as dykes or as marginal modifications of plutonic masses, magmatic differentiation having played an important part in their origin.

In the present instance, all the members of the series have been formed by magmatic differentiation from an original magma with a composition intermediate between the most acid and most basic members of the series; and it may be guessed, judging from an estimate of the relative abundance of the members of this series, that the composition of this original magma was probably that of quartz-kodurite. The various members of these series are so related that all must be regarded as of the same origin, and consequently the ultra-basic rocks must be included in the same series as the more acid members. In fact, it seems to me desirable, when one is considering a series of related plutonic igneous rocks, to add the customary ultra-basic division to Hatch's scheme, which can easily be done by fixing a SiO_2 percentage as the boundary between the basic and ultra-basic divisions. But it must be noted that such ultra-basic rocks would often be completely devoid of any felspars, as in the present case, and that the ultra-basic rock would be assigned to its respective series, not on the merits of its own mineral composition, but on that of its less basic magmatic associates. Thus, in the present case, spandite-rock falls into what may be regarded as the mangan-subdivision of the potash series on account of the potassic nature of the felspar in kodurite.

Composition of kodurite and shonkinite.

Above, I have correlated the members of the kodurite series with those of the potash series, and it is easy to notice the general chemical similarity of the corresponding sub-divisions, one of the chief chemical distinctions between the two series lying in the high percentage of manganese oxide in many of the members of the kodurite series. To emphasise still more clearly the chemical similarities and differences, I place side by side in the following table analyses of shonkinite and of kodurite.

—	Shonkinite.[1]	Kotakarra kodurite.	Boirani kodurite.
SiO_2	46·73	47·45	53·36
Al_2O_3	10·05	18·00	16·31
Fe_2O_3	3·53	1·91	4·17
FeO	8·20	4·10	0·79
MnO	0·28	9·08	0·98
MgO	9·68	0·13	0·22
CaO	13·08	10·37	12·54
K_2O	3·76	6·97	9·75
Na_2O	1·81	..	0·33
H_2O	1·24	..	..
TiO_2	0·78	0·29	0·24
P_2O_5	1·51	1·42	1·11
CaF_2	..	0·26	0·20
$CaCl_2$	0·28	..	..
CuO	..	0·02	..
TOTAL	100·93	100·00	100·00

From the above it is seen that the typical kodurite contains practically no magnesia, the place of which is taken by about the same quantity of manganese protoxide. It contains nearly 6 per cent. less oxides of iron, but 8 per cent. more alumina, whilst it contains nearly 7 per cent. of potash against 5½ per cent. of total alkalies in shonkinite.

The differences and similarities may be further followed by comparing the norms of the respective rocks, as in the following table :—

Mineral.	Formula.	Shonkinite.	Kotakarra kodurite.	Boirani kodurite.
Orthoclase	$K_2O.Al_2O_3.6SiO_2$	22·24	35·47	55·32
Leucite	$Ka_2O.Al_2O_3.4SiO_2$	..	4·53	1·83
Nephelite	$Na_2O.Al_2O_3.2SiO_2$	8·38	..	1·50
Anorthite	$CaO.Al_2O_3.2SiO_2$	8·06	28·44	14·15
Diopside	$CaO. (Mg,Fe) O.2SiO_2$	38·55	..	1·19
Hedenbergite	$CaO.FeO.2SiO_2$	..	11·02	..
Wollastonite	$CaO.SiO_2$	..	0·93	16·83
Olivine	$2(Mg,Fe)O.SiO_2$	12·24	..	..
Tephroite	$2MnO. SiO_2$	..	12·93	1·39
Magnetite	$FeO.Fe_2O_3$	5·10	2·76	1·86
Hematite	Fe_2O_3	..	..	2·89
Ilmenite	$FeO.TiO_2$	1·47	0·55	0·46
Apatite	$3(3CaO.P_2O_5)+Ca(F,Cl)_2$	3·53	3·33	2·62
	TOTAL	99·57	99·96	100·04

[1] W. H. Weed and L. V. Pirsson : *Bull. Geol. Soc., Amer.*, VI, p. 414, (1895).

Before leaving this table, it should be noted that the shonkinite analysis represents the rock as actually found in Shonkin Sag, and it appears as if there is a somewhat important difference between shonkinite and the typical kodurite, lying in the 8 per cent. of nephelite in the former rock. Weed and Pirsson, however, in their original description of the rock, propound the term *shonkinite* for "a granular plutonic rock consisting of essential augite and orthoclase," and regard the shonkinite of Shonkin Sag as an olivine-shonkinite with accessory nepheline.

Classification of kodurite series if hypabyssal.

Reverting to the table on page 222, it is noticed that the most acid member of the series—quartz-orthoclase-rock—differs from a true potash-granite in the absence of any micas, hornblendes, or pyroxenes, or the equivalent garnets; in fact, this rock is one which Hatch, following Brögger, would treat as belonging to the leucocratic group of the hypabyssal rocks (see pp. 211, 227, and 228, of his Text-book of Petrology, 5th edition), and the treatment of the kodurite series consonant with Hatch's Text-book would be to place the whole series amongst the differentiated hypabyssal rocks and regard it as having broken into two complementary segments, *leucocratic* and *melanocratic.* But if one comes to details, this sub-division is not so easy to carry out, because there is a gradation from the most acid member of the series to the most basic, although one could easily class the acid and intermediate divisions as leucocrates, and the remaining divisions as melanocrates. In fact, the rocks have solidified before the differentiation was complete, and there has not been any separate eruption of the different units. From the field evidence it is difficult to decide whether these rocks should be regarded as truly plutonic or as hypabyssal; but, in spite of the relatively small size of the occurrences of this series, I am inclined to consider them as plutonic rather than hypabyssal.

Elasticity of Hatch's classification.

The point to which I would draw the attention of the American petrographers is the elasticity of Hatch's classification. In the present case, we have a series of rocks the members of which are genetically related. We are not certain whether the series is to be regarded as plutonic or as hypabyssal. If the former be the truth, we can add a mangan-subseries to the potash series of the plutonic rocks. If the latter be the truth, we can split the series into two families, one of which falls into the leucocratic group

of the differentiated hypabyssal rocks and the other into the melanocratic group. At the same time, the relationship of the rocks of the series, one to another, is preserved. Were one to ascertain the position in the Quantitative Classification of each member of the kodurite series, they would be found to be scattered over many parts of the classification, dissociated from each other and associated in many cases with totally unrelated rocks.

C.—Comparison of the two methods.

Summing up our deductions as to the relative ability of these two classifications to deal with the kodurite series, we may say that the Quantitative Classification has proved itself inelastic and incapable of dealing with the kodurites without introducing modifications unsanctioned by its authors, whilst it scatters about the various members of this series, as it would of most other series; further, it can only deal with such a series by the creation of a small host of names of barbarous sound to which one travels through a forest of equally terrifying adjectives. On the other hand, Hatch's classification is so elastic that it can satisfactorily assimilate the whole series, whether it be regarded as of plutonic or hypabyssal origin; it marshals the rocks of the series in their proper relationships one to the other; and, lastly, the names already proposed are sufficient.

III.—THE QUARTZ-BARYTES-ROCK OF SALEM.[1]

In 1897, Sir. T. H. Holland[2] described a quartz-barytes rock forming a large proportion of two low hills between Mittur and Alangayam in the Salem district, as well as a complex of veins traversing the neighbouring crystalline rocks (pyroxenic gneiss and augite-diorite), up to a distance of 5 miles in one direction and 2 in another from the main plexus. He arrives at the conclusion that the quartz and barytes are the normal original constituents of this plexus and that they separated from an injected mobile magma like many commoner pegmatites of a different composition, although "no evidence is forthcoming concerning the temperature of the magma prior to consolidation." The remark quoted applies to many more normal

[1] Although not comprised in the title of this paper the consideration of this rock may be appropriately included.

[2] *Rec. G.S.I.*, XXX, pp. 236-242, (1897).

pegmatites, and it seems fair to test the Quantitative Classification by investigating its ability to classify this abnormal rock.[1]

As the result of specific gravity determinations on 60 specimens of the rock, Holland arrives at the following average percentage composition for the rock :—

Quartz	69·2
Barytes	30·8

The barytes itself is found to possess the following composition :—

$BaSO_4$	94·15
$CaSO_4$	4·01
Fe_2O_3 & Al_2O_3	0·93
SiO_2	0·63
Moisture and loss on ignition	0·30
	100·02

For the purposes of calculation we may neglect the oxides of iron and alumina and the last item, and take as the average composition of the rock :—

SiO_2	69·4		
$BaSO_4$	29·3	BaO	19·3
		CaO	0·5
$CaSO_4$	1·3	SO_3	10·8

As there is no other way of rearranging the constituents of the rock, both the norm and the mode may be stated as :—

Quartz	69·4
Barytes	29·3
Anhydrite	1·3
	100·0

[1] F. W. Clarke, 'Data of Geochemistry,' *Bull.* No. 330, *U. S. Geol. Surv.*, p. 500, (1908), discussing this case, says that the mode of origin accepted by Holland is chemically improbable, because in a molten state quartz (or free silica) would react upon barium sulphate to form a silicate with liberation of sulphuric acid or sulphur dioxide. There is no natural mineral $BaSiO_3$, and although $BaSiO_3$ has been prepared artificially, I can find no record of its specific gravity. But the reaction, $CaSO_4 + SiO_2 = CaSiO_3 + SO_3$, involves a 31% decrease in volume of the solid constituents. The analogous reaction for barium would doubtless also show a large decrease, and therefore we should expect the reaction postulated by Clarke to take place whilst the molten rock was under considerable pressure. If, however, the SO_3 was for any reason unable to escape, I see no reason why, on reaching the lower temperatures and pressures that may have prevailed during the intrusion of these veins, the sulphuric acid, formed by union of SO_3 with water, should not have become a more powerful acid than the silicic acid and have reversed the reaction, with the resultant production of a quartz-barytes rock.

Neither barytes nor anhydrite have been included in the list of standard minerals on pages 115 and 116 of the Quantitative Classification, but there is little doubt that they should be classed with the femic minerals in the A sub-group, containing apatite, fluorite, calcite, pyrite, etc.

We may now attempt to classify the rock as follows :—

$\frac{Sal}{Fem} < \frac{7}{1} > \frac{5}{3}$. $\therefore$ Class II—Dosalane.

$\frac{QFL}{CZ} > \frac{7}{1}$. $\therefore$ Sub-Class I.

$\frac{Q}{F} > \frac{7}{1}$ $\therefore$ Order 1—perquaric—no representative.

The SO_3 might next be dealt with by the formation of sub-orders on the basis of ratios of quartz to sulphates, with a five-fold sub-division, $\frac{Q}{S} = \frac{69 \cdot 4}{30 \cdot 6} < \frac{7}{1} > \frac{5}{3}$. $\therefore$ Sub-order 2—dosilicic.

It should be noticed, however, that a large number of quartz-veins and very siliceous pegmatites, which must in many cases be regarded as igneous rocks, must fall into this same order, and it might be desirable in treating such rocks systematically, to use some other criterion than the abundance of sulphates for forming sub-orders. In any case, the rock high in sulphates is found to be *dosilicic*, so that the sulphate is not expressed in this way.

In order to attempt to proceed further with the classification of this rock, the BaO must be regarded as CaO″. It then appears that the rock cannot be further classified at all, because the ratios used in the formation of rangs, subrangs, grads and subgrads are completely inapplicable. The quartz-barytes-rock has, therefore, to remain classified in the dosilicic sub-order (2) of the perquaric order (1) of Class I, grouped with any other very quartzose rocks in which the ratio of quartz to minerals containing other acid radicals than SiO_2 is $< 7/1 > 5/3$. The method seems to have failed completely, as we have not succeeded in giving any classificatory weight to either the BaO or the SO_3.

IV.—CONCLUSION.

In view of the vast time, thought, care, and ingenuity, applied by the four eminent American petrographers to the construction of their Quantitative Classification (see p. 99 of their work), it is only with great hesitation, and after actual trial, that one may venture

not to adopt it in place of the admittedly unsatisfactory methods of classification of igneous rocks, as expressed in Rosenbusch's and Zirkel's great works in German, and in the text-books of Harker and Hatch (earlier editions) in English. Further, I, personally, am not the one to object to the large number of new mnemonic nouns and adjectives invented, however uncouth and barbarous they may sound until one's ear and eye becomes inured, if it can be shown that any real service is done to petrographical science by their introduction. Apart from the defects in the system revealed by my treatment of the kodurite series, and those pointed out by Evans in the article cited, the system, even if logically perfect, would be quite unsuited for use by the working petrographer in the field, owing to its foundation upon the basis of complete quantitative chemical analysis. This unsuitability of the system is recognised by the authors, and they consequently propose a separate system of nomenclature for field use (*l. c.*, pp. 180-185), in which the primary sub-division is into *phanerites* and *aphanites*, terms which explain themselves. The phanerites are then subdivided into five groups—granite, syenite, diorite, gabbro, and peridotite-pyroxenite-hornblendite—the more exact modern meanings of these terms being abandoned and a return made to their earlier meanings according to Werner, von Leonhard, and d'Aubuisson. This return, seems, however, most undesirable,[1] as likely to lead to great confusion.

There is, however, no doubt that quantitative considerations must be introduced into petrographical classification if this branch of science is to progress. It seems to me that Hatch has very skilfully grafted certain of the American ideas upon the ordinary classification of plutonic rocks, and has built up the skeleton on which a really serviceable classification may be moulded. A similar classification is applicable to the volcanic rocks,[2] whilst, for the hypabyssal rocks, the method of first subdividing them into *undifferentiated* and *differentiated* rocks, and then treating the undifferentiated hypabyssal rocks on lines analogous to those adopted for the plutonic rocks, whilst applying to the differentiated rocks Brögger's conception of complementary types, seems peculiarly well suited to our present knowledge.

One is, therefore, compelled, though reluctantly, to deny the suitability of the American system for all ordinary purposes; but

[1] Except for commercial purposes, with reference to building stones.
[2] Hatch's Text-book, p. 248.

one must recognise the great influence it is destined to have on the petrography of the future by compelling petrographers to introduce quantitative notions into their classifications. Hatch's attempt is the first evidence of his influence.

For purposes of detailed investigation of related rocks, it is possible, however, that the American classification may be of the greatest value. Thus, although one prefers to subdivide the granite family into the four sub-families—soda-granite, potash-granite, adamellite, and granodiorite—instituted by Hatch, yet, if one wished to study and compare all the known granites from all over the world, it would probably be very helpful to classify them into all the different rangs, subrangs, grads and subgrads, for instance, into which they would fall.

In the discussion on Whitman Cross' paper, 'The Natural Classification of Igneous Rocks', *Q. J. G. S.*, LXVI, pp. 470-506. (1910), the English petrographers present made unfavourable comments on the quantitative system. Whilst agreeing with them in most respects, I ventured to express the opinion that the idea of the *norm* might be of great value in enabling one to compare one rock with another irrespective of the accidents of consolidation. Recently I have been making use of the norm, and must state at once that I find it of the utmost value. By its aid one is translated from the province of p trography lying at one end of the petrological domain to that of petrogenesis lying at the other.

By the application of this idea of the norm to various series of rocks, both Indian and foreign, I have arrived at several petrogenetic conclusions, some of which appear to me to be of general interest; but, as the investigation is not yet complete, I must postpone their development and discussion to the next part of these *Records*.

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RECORDS

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A GEOLOGICAL RECONNAISSANCE THROUGH THE DIHONG VALLEY, BEING THE GEOLOGICAL RESULTS OF THE ABOR EXPEDITION, 1911-12. BY J. COGGIN BROWN, M.SC., F.G.S., A.M.I.M.E., *Assistant Superintendent, Geological Survey of India.* (With Geological Sketch Map,) Plate 27.

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INTRODUCTION.

OUR previous knowledge of the geology of the interior regions of the mountains bordering the plains of Upper Assam had been slowly gathered together, almost without exception, during the progress of punitive expeditions against one or other of the hostile tribes inhabiting them.

East of Bhutan two geological traverses have already been made into the outer ranges of the Eastern Himalaya, the first by Lieutenant-Colonel H. H. Godwin-Austen in 1875, when he visited the Daphla Hills with the force then operating there[1]; and the other by T. D. LaTouche in 1883, when he accompanied an expedition against the Akas, a tribe occupying the Lower Himalayas to the north of Tezpur in Assam, between the Bhutanese and the Daphlas.[2]

In November of last year (1911), I was deputed to accompany the Expeditionary Field Force which was proceeding against the Minyong Abor clans living in the valley of the Dihong. The notes which make up this report are the results of my observations, and are incomplete enough to draw attention to the fact that the ordinary difficulties of the geologist in very mountainous country, covered for the greater part with unbroken forest and enjoying an exceedingly high rainfall, are not lightened by the necessity of working during the progress of a military campaign.

It was anticipated that the general sequence of geological formations recognised at different times in the sub-Himalayan zone,—by F. R. Mallet in the Darjeeling Terai and the Buxa Duars,[3] by G. E. Pilgrim in the foot hills of Bhutan,[4] and by H. H. Godwin-Austen and T. D. LaTouche in the Daphla and Aka countries respectively,—would be more or less followed in the Abor Hills. This surmise has proved correct, and the results that I am now able to bring forward lend confirmatory evidence to the belief, that stretching from Nepal in the west at least as far as the Dihong valley in the east, there are more or less continuous bands of strata of the Metamorphic (probably pre-Cambrian), Gondwana, and Upper Siwalik systems, flanking and running roughly parallel to the central crystalline axis of the Himalaya itself. Although it will probably be many years before the intervening gaps are all filled in, owing to the hostility of the wilder hill tribes as well as to the immense difficulties of work and transport

[1] H. H. Godwin-Austen: "Notes on the Geology of part of the Dafla Hills, Assam, lately visited by the Force under Brigadier-General Stafford, C.B." *Journ., As. Soc. Beng.*, Vol. XLIV, pt. 2, 1875, pp. 35-41.

[2] Tom. D. LaTouche: "Notes on the Geology of the Aka Hills, Assam," *Rec., Geol. Surv. Ind.*, Vol. XVIII, (1885), pp. 121-124.

[3] F. R. Mallet: "Geology of Darjiling and the Western Duars," *Mem., Geol Surv. Ind.*, Vol. XI., (1875).

[4] G. E. Pilgrim: "Notes on the Geology of a portion of Bhutan," *Rec., Geol. Surv. Ind*, Vol. XXXIV, (1906), pp. 22-30.

in such regions; yet it is contended that the broader geological features may be assumed with much less hesitation than before, and used in our endeavours to solve the geological history of these eastern parts of the great chains.

I would here express my indebtedness to Major-General Bower, C.B., General Officer Commanding the Abor Expeditionary Field Force, for opportunities given me to make geological investigations and especially for my appointment as a member of the Dihong Exploration Column. My thanks are also due to many officers of the Staff, of the 2nd and 8th Gurkha Rifles, of the 32nd Sikh Pioneers, and of the 1st King George's Own Sappers and Miners, for assistance in my work. I am especially indebted to Captain O. H. B. Trenchard, R.E., Survey of India; to Captain Sir George Duff Sutherland Dunbar, Bart., Commandant, Lakhimpur Military Police; to Captain Charles Melvill, I.M.S., Staff Surgeon; to Mr. A. Bentinck, I.C.S., Assistant Political Officer; and to my colleagues of the scientific party Messrs. S. W. Kemp, I. H. Burkill, and J. Millroy.

Maps.

The only available map was that issued to officers with the Abor handbook at the commencement of the expedition. This was on the scale of 1 inch to 4 miles, and was accurate as far north as Kebang in the immediate vicinity of the Dihong. Beyond this point all positions had been conjectured and proved to be totally incorrect. By the courtesy of Captain O. H. B. Trenchard, R.E., who was in charge of all topographical surveys, I was given tracings of the new map under construction, and by this means was able to locate the features of geological interest with the help of geographical notes made while on the march.

Recent Alluvium.

J. M. Maclaren has already pointed out that the alluvium of the Upper Assam valley may be divided, to a more certain degree than that of any other Indian river, into the two regions of "*bhangar*," or higher land, and "*khadar*," or low land subject to annual flooding.[1] Both the Dihong from the point where it leaves the hills up to its junction with the Lohit, and the Brahma-

[1] J. M. Maclaren: "Geology of Upper Assam," *Rec., Geol. Surv. Ind.*, Vol. XXXI, (1904), pp. 179-204.

putra from this point down as far as Dibrugarh, are fast-flowing rivers with currents of considerable strength, and, although peculiarly liable to rapid rises or sudden floods, are more or less confined to their banks. Great areas of country are however submerged in the rainy season below this point. Quite apart from the fact that it is a heavily silt-laden river, the fall of the bed in this upper region is too great to allow of any extensive deposition, so that gravel and pebble beds are seldom seen. In the few pebble beds of the Brahmaputra proper and in the Dihong from the Lalli Mukh up to Jawpong—an outlying Pasi Abor village on the alluvium,—the greater part of the material was found to be well rounded and the pebbles on an average 4 to 6 inches in length, often deposited so as to show the direction of the current. White and pink quartzites, hard sandstones, decomposed traps and volcanic ashes predominate, while granite and gneiss are very rare.

From Jawpong to Pasighat the current of the Dihong becomes swifter, rapids are of more frequent occurrence and there are greater evidences of denudation. The boulders too become larger, though they still consist of much the same material.

The flat alluvial plain stretches north from Kobo to the foot of the hills as far as Pasighat. In every direction it is covered by dense forest, save for a few open patches or "*chapris*" where tall rank grasses flourish. This area is practically uninhabited and the luxuriance of the vegetation entirely masks the ground. With the recent alluvium must be classed the pebble and boulder banks and the masses of earthy debris which the excessive denudation of the present day is producing. The former are to be found about the debouchure of the river and smaller streams, and the latter forms the gently rising ground which occurs towards the base of the foot hills, and often contains very slightly worn fragments of the local rocks.

Pleistocene River Terraces.

Both the latter types of deposits are to be carefully distinguished from the Pleistocene river terraces which form such a constant geological feature along the hills at the foot of the Eastern Himalayan chain, and which have also been recorded by T. D. La Touche in the valley of the Upper Dihing and in that of its principal tributary the Dapha. There, three terraces exist 250, 160

and 140 feet in height respectively, and the surface of the oldest reaches 1,000 feet above the level of the valley.[1]

Marching north from Pasighat, the road crosses level alluvium for 1½ miles and then commences a steep ascent over Pleistocene deposits overlaid on a core of Siwalik rocks. Before Janakmukh is reached the Siwaliks themselves are seen outcropping, and in the bed of the river, a quarter of a mile below the camp a raised river-terrace section, 150 feet thick, caps a cliff of Siwalik sandstones 200 feet high, so that the top of this terrace is 350 feet above the present level of the Dihong. A certain rude stratification is developed and the terrace contains at least two well marked beds of sand. The boulders and pebbles contained in it are the same as those found in the river-bed at the present day. The top surface of this terrace seen from a distance appears to be level, and there are also traces of a higher one exposed in a landslip to the west. This terrace is comparable with that found by J. M. Maclaren at Mishmighat where the Lohit Brahmaputra leaves the hills, or with those noticed by the same geologist on the way to the Brahmakund.[2]

It is probable that the wanderings of the rivers over the plains during a long course of time have removed by erosion considerable thicknesses of these Pleistocene deposits, and to this cause must be put down their absence at the actual debouchure of the Dihong.

Further west, elevated river gravels and hills of confused drift are found, as for example near Balek, where immediately opposite the new stockaded post a section is exposed in the steep side of a stream-bed. This consists almost entirely of unstratified clay with boulders of various sizes of Tertiary sandstones. Again, at the Pasi Abor village of Bakang, a quarter of a mile below the stockade, a Pleistocene terrace 60 feet in thickness is well exhibited. Small water-worn sandstone boulders strew its face, down which the path runs on to another and smaller terrace some 20 feet thick just below. No opportunity for making a traverse to the north in this area was afforded, but it is probable that these deposits continue further in some way towards the Siwaliks, though I do not think that they attain the height of 800—900 feet which the Pleistocene drift deposits seen by T. D. LaTouche at the base

[1] T. D. LaTouche: "Geology of the Upper Dihing basin in the Singpho Hills," *Rec., Geol. Surv. Ind.*, Vol. XIX, p. 114.
[2] J. M. Maclaren: *loc. cit.*, p. 195.

of the Aka Hills reach.[1] It seems certain, however, that the low-lying outermost ridge which can be observed to the north from Dibrugarh and which is continuous for some distance along towards the east, as is so well seen during the journey up the Brahmaputra from Dibrugarh to Kobo, is partly, if not entirely, made up of terrace and drift deposits of this period.

In the absence of a large-scale topographical map it is impossible to survey accurately the various terraces or to draw their boundaries definitely, and I have therefore shown them as a generally continuous band. The exposure of these old gravels is due, as Maclaren has noted, to an increase in the steepness of the slope of the river valley, whereby the deposits at its head are cut down until the natural slope under the conditions which prevail is reached, but whether this change has been effected by elevation of the head of the valley or, by depression of its lower portion is still an open question.

Siwalik Series.

The Siwalik series was only crossed in one place,—the main line of march up the Dihong valley followed by the expedition, and I have therefore few observations to make upon it. After leaving the alluvium and commencing the ascent over a spur between Pasighat and Janakmukh, large blocks of hard white sandstones are found about the hillside, but not *in situ*. Near Janakmukh massive bands of softer but coarser material, often containing numerous small quartz pebbles, are seen. Below the camp at this place soft, greyish, speckled black, micaceous sandstones outcrop which sometimes contain nests of bright lignite or carbonaceous shale. These fragments of coal, undoubtedly formed from pieces of drift wood deposited during the formation of the sandstones, have given rise in certain quarters to the hope that extensive coal-seams might be found in them; from what I have seen of these rocks I do not think that this is at all likely. Just beyond the camp the dip is 50° to the north-west, but this varies as much as 10° more or less owing to local contortion. Micaceous sandstones of the pepper and salt type continue along the northern road which runs along the right bank of the Dihong, and their softness and habit of outcropping in cliffs were sources

[1] T. D. LaTouche: *loc. cit.*, p. 122.

of great trouble in road-making operations. At the second mile they are followed by hard white sandstones and quartzites, the dip becomes higher in the opposite direction whilst the strike remains the same. From this point there is a gradual ascent to an open clearing,—an old Abor "*jhum,*" known as Rammidumbang, which has an elevation of 2,000 feet above sea-level. There are no exposures up to the top, but the ground is covered in places with rough blocks of hard Siwalik sandstone. From this elevation an excellent view of the debouchure of the Dihong into the plains is obtained. The wide break which it makes through the Siwaliks is very well marked, the tops of the ridges on either side exhibiting a curious conical appearance ending in sharp peaks with almost symmetrical sides. Landslips are very common, and the light-coloured Tertiary strata show up well against the dark green of the true sub-Himalayan rainy forest which covers the hills in every direction. The dip as seen in the landslips around appears to be to the north-west, and it is from the lie of the country from this point that I have drawn in the junction of the Siwaliks with the older Gondwana strata.

J. M. Maclaren has demonstrated the absence of these Tertiary strata in the vicinity of the Brahmakund and for some 25 miles to the north-west along the flanks of the schists, and thinks that their first appearance on the north bank of the Brahmaputra,—judging from the outlines of the hills—" is in the vicinity of the old Ahom walled city of Bishemnagar," whence they extend north-west and wrapping around the debouchures of the Dibong and Sesseri enter the area under description.[1] There is an unvisited gap between this point and the country north of Dibrugarh visited by H. B. Medlicott in 1865,[2] and the neighbourhood of the Subansiri, where the typical sandstones attain a great thickness, but there need be no doubt as to the continuity of the belt to these points, whence it is supposed to run to the classic ground of the Siwaliks themselves. The apparent absence in the Abor country of those thin shale and clay bands which are found in these rocks elsewhere, is probably due to the paucity and imperfect nature of the available exposures. It is probable that the fossil elephant's tooth mentioned by H. B. Medlicott as having

[1] J. M. Maclaren: *loc. cit.*, p. 193.
[2] H. B. Medlicott: " Geological Notes on Assam," *Mem., Geol. Surv. Ind.*, Vol. IV, p. 436.

been found in the gorge of the Deijmoo, (Dirjmur) north of Dibrugarh, really belonged to the living species *Elephas indicus*, as several were picked up in similar places during the Abor expedition.

Gondwanas.

Rocks belonging to this system have previously been described from every other part of the Eastern Himalaya which has been geologically examined, and it was therefore thought that they would be met with beyond the Tertiary zone in the Abor hills. F. R. Mallet was of the opinion that they occurred in small lenticular outcrops and mapped them as such in the Baxa Duars.[1] G. E. Pilgrim [2] however has shown that it is not impossible for the band to be more continuous than this, the special circumstances which tend to prevent its discovery being the completeness with which the coal-seams and softer beds are concealed by the thick soil-cap and jungle, and the resemblance which some of the Gondwana quartzites and graphitic schists bear to similar beds belonging to the older metamorphic system. Unfortunately no actual contact of the Siwaliks and the Gondwanas was met with, but it is believed that the junction is marked by an overthrust as is the case everywhere else. No fossils were obtained from the beds, but their lithological characteristics and their position are sufficient to identify them. The commonest types met with are white and greyish white, indurated sandstones and quartzites, reddish, ferruginous shales, black carbonaceous shales often with clay-ironstone, septarian nodules, hardened, greyish blue shales in which a schistose structure has been developed, and coal-seams.

Description of road section across the Gondwanas.

Near the top of the ascent from the open clearing of Rammidumbang the soil becomes black and at the crest of the lower ridge there is a small outcrop of a highly contorted, black carbonaceous shale which is coaly in places. The road still ascends, until the "coolie kol" is reached after which it descends gradually to the Sirpo stream. Hard white sandstones, contorted grey slates, contorted reddish-brown and reddish-purple shales are the commonest rocks, but nodular black shales and hardened greyish-

[1] F. R. Mallet: "Geology of Darjiling and the Western Duars," *Mem., Geol. Surv. Ind.*, Vol. XI.

[2] G. E. Pilgrim: "Notes on the Geology of a portion of Bhutan," *Rec., Geol. Surv. Ind.*, Vol. XXXIV, p. 24.

blue shales with a quasi-schistose structure are also seen. Dense jungle covers the whole country and as outcrops are small and rare, it is impossible to obtain a continuous section or to unravel the inter-relationships of the various rock types. At the Sirpo stream a fine-grained, light grey quartzite is developed, which under the microscope, is seen to consist of small angular grains of quartz exhibiting strain shadows, set in a finer quartz matrix. Flakes of a pale mica and fragments of magnetite are the only other minerals present. Carbonaceous shales are interbedded with the quartzites, and in one place there is a coal seam 4 or 5 feet thick. Other patches of coal were also found in the neighbourhood, and it seemed as though they might once have formed continuous seams, having assumed their present lenticular condition as a direct result of the intense crushing to which they have been subjected. The coal too bears evidence of the same disturbing forces, for it is exceedingly friable and powdery, and falls to pieces when handled. These beds bear a remarkable resemblance to similar ones found in the Darjeeling Damudas and concerning which F. R. Mallet wrote as follows :—" At the same time, the crushing to which the seams have been subjected, has squeezed them so that they vary greatly in thickness within a few yards, and has induced a flaky structure in the coal itself which renders it so friable that it can be crumbled into powder between the fingers with the greatest ease. This flakiness is in fact true cleavage, and the mineral may in one sense be regarded as a coal slate."[1]

Between the Sirpo stream and Renging, black, contorted carbonaceous shales and slates are the commonest rocks, but hard fine-grained sandstones simulating limestones, and hardened red shales were also found. At Renging a hard, coarse, grey, indurated sandstone interbedded with thin bands of dark grey slate strikes north 60° east and dips south 30° east at 51°. The dip, however, varies greatly and becomes nearly vertical a few yards further to the north.

Gondwanas exposed in the Upper Sireng Valley to the south-west of Kalek.

A traverse was made up the valley of the Sireng from Rotung. By far the greater part of the route crosses typical rocks of the Abor Volcanic Series, but, near the point where the Kalek-Mishing road crosses the Sireng, sandstones and shales of

[1] F. R. Mallet: *loc. cit.*, p. 15

the Gondwana beds themselves were found. The arbitrary line which I have drawn separating the Volcanic Series from the Gondwanas proper near Renging comes into much the same strike here, as a glance at the map indicates.

A feature of more than usual interest, however, is the rare occurrence of rolled limestone boulders in the upper course of the river, that is to say in its narrow head valley, overlooked by the high spurs of Torne Hill among which it rises. Hampered by the difficult nature of the area and by want of time, I was unable to locate the beds from which the boulders come, but those which were seen were composed of a dark bluish-grey, slightly arenaceous limestone with generally indeterminable fossil remains, but including badly preserved crinoid ossicles. These rocks undoubtedly belong to the base of the Gondwana series, and must occur somewhere in the steep, jungle-covered ravine slopes of the upper Sireng.

Their interest lies in the light which they throw on those boulders of fossiliferous Permo-Carboniferous limestone found in 1903 by J. M. Maclaren at the mouth of the Subansiri gorge,[1] and from which C. Diener has described a small Anthracolithic fauna.[2]

It has been generally believed that these fossils have been brought from the head-waters of the Subansiri, which was supposed to cut its channel through the main Himalayan range, and to have its sources on the edge of the Tibetan plateau. The recent survey work in the Subansiri valley, accomplished during the course of the Miri Mission (1911-12), though not finally disproving the contrary, has made it exceedingly doubtful whether the Subansiri or any of its principal feeders break through this chain. In the light of the Sireng occurrences we are forced to the opposite conclusion first brought forward by J. M. Maclaren, that the locus of these fossiliferous beds may be looked for at the base of the Damuda series at no very great distance from the plains of Assam. The beds in the Abor hills in this position appear therefore to indicate roughly a point on the northern coast line of Gondwanaland, or at any rate its very close proximity.

[1] J. M. Maclaren : *loc. cit.*, pp. 186-187.

[2] Prof. C. Diener : " Notes on an Anthracolithic Fauna from the mouth of the Subansiri Gorge, Assam," *Rec., Geol. Surv. Ind.*, Vol. XXXII (1905), pp. 189-198 ; in this connection see also T. H. Holland : " General Report, Geological Survey of India, 1903-04," *Rec., Geol. Surv. Ind.*, Vol. XXXII, pp. 153-154.

Abor Volcanic Series.

Beyond Renging there is a great development of decomposed traps, which in hand specimens are usually of dirty grey shades with white markings, indicating the position of kaolinized felspar crystals. Owing to the vegetation, and the rapidity with which observations had to be made while marching with fast-moving convoys, the details collected regarding this interesting group of rocks are somewhat scanty, and all that can be done is to give an account of such exposures as were met with on the direct line of march. If the dips seen at Renging are taken as correct, the traps and associated rocks are older than the quartzites, slates and indurated shales found between that place and Rammidumbang. This however is uncertain. Owing to the interbedding of contemporaneous volcanic bands before they attain their maximum development further to the north, with rocks identical in every respect with the Gondwanas proper between Renging and Upper Rotung, their age is established. At the same time the sub-division in the system to which they should be allotted will remain a matter of doubt until further work is done on them.

H. H. Godwin-Austen in 1875 was the first to draw attention to the existence of volcanic rocks in the Eastern Himalaya. In the Daphla Hills he found the Gondwana coal-seams and associated rocks succeeded by white quartzite beds, but, having nowhere discovered an actual contact, came to the conclusion that they belonged to F. R. Mallet's Daling series. He writes as follows :—" On the road to the bridge built by the force above Camp No. 6, a dark green rock is conspicuous by its very trappean appearance: at the bridge a very white quartzite underlies it, dipping 55° south-east."[1]

Road Section Renging to Rotung.

The decomposed beds of trap which outcrop beyond Renging camp continue to the top of the kotal from which the last view of the plains is obtained. Here poor exposures of carbonaceous shales are visible. They are followed at once by white and pinkish white quartzites, with thin green and bright red shale bands, interbedded with which are numerous lava beds extending for over a mile. At the top of the ridge down which the road zigzags to the smaller branch of the Egar river, there is a very well marked

[1] Godwin-Austen : *loc. cit.*, p. 39.

outcrop of the same kind of rock, but quartzites come in again at once and continuing up the Razor Edge ridge, and then across the main branch of the Egar stream, reach a point a mile and a half below Upper Rotung camp. At this point hardened shales with an occasional sandy parting crop out but only for a short distance, when they are replaced by traps which appear to make up the rest of the country as far as Rotung.

This succession is not continuous, and there are often gaps where all outcrops are entirely masked. The exposures too are very broken up, the quartzites especially weathering down into cuboidal fragments which strew the path. The dip near Upper Rotung is 60° to the south-west, but further to the north the strike seems to veer more to the east. Near Rotung stockade loose pieces of amygdaloidal volcanic rock and a few large blocks of volcanic agglomerate can be seen on a "*jhumed*" hillside.

There is therefore no doubt about the contemporaneousness of these traps with rocks exactly similar to those found associated with coal-seams a little further to the south, and the line separating the Gondwanas from the Abor Volcanic series merely marks off the area in which the latter attain their greater development and are freer from other deposits.

Volcanic Series around Rotung.

Rotung stockade is situated on a flat "*jhumed*" expanse overlooking the Dihong and some 1,000 feet above it. The path winds down the precipitous sides of the gorge-like valley through which the river here runs, and dense forest masks all outcrops, but in the actual bed of the river excellent exposures are obtained, consisting of massive lava flows of dark green and dark reddish rocks, generally containing amygdaloidal cavities filled with chalcedony, opal and clear quartz. Green and red jasperised bands are common and are probably the result of infiltration. The whole series strikes approximately east and west and dips north-north-east at 50°.

Road Section Rotung to Yambung.

Between Rotung and Yambung, (which is just below the Abor village of Kebang), similar decomposed traps alternate with quartzites, and just below Yambung camp an accessible cliff section displays hard white and reddish white quartzites, blackened and polished within the flood level of the river. There are also thin bands of purple shale and one or two layers of metamorphosed shale to be seen. The dip here is at 55° to the north-west.

The nearest outcrop of igneous rock along the road is situated ½ mile to the south of Yambung camp, and consists of a fine-grained grey basalt with a few small cloudy quartz geodes. Under the microscope this rock is seen to be made up of a felted mass of small, lath-shaped, plagioclase felspar crystals set in a decomposed chloritic ground mass, which also contains small grains of magnetite and small decomposed augite crystals.

The Abor Volcanic Series in the neighbourhood of Riu.

The series is next met with in the neighbourhood of Riu, though the Abor track followed by the exploration column between Komsing and that place kept for the most part over soil and jungle-covered slopes, where exposures were exceedingly poor. The only rocks visible along the eight miles of road separating these two villages being dark greyish-blue decomposed amygdaloidal lavas, interbedded with shale-like tuffs and with purple and greenish slaty shales, with an occasional brownish red sandstone parting.

Riu itself is situated on a steep hillside at an elevation of 2,050 feet above the sea and some 1,250 feet above the Dihong. There is a steep descent to the river across reddish tenacious clay, the product of the weathering of the traps. The river-bed is here about 200 yards wide, and the flood level over 70 feet above that of the winter. Excellent exposures of the traps are seen on both banks, the flows being very massive and little weathered, and sometimes showing a rough prismatic jointing. Hard white and reddish-white, massive quartzites are in places interbedded with the traps. The general strike is north 18° west, and the dip at 44° in an easterly direction.

Traces of volcanic rocks are found beyond Riu on the steep descent which the northerly road makes to the Ebung stream, but, after crossing this, greyish white quartzites are followed by a succession of traps interbedded with purple shales and quartzites until the road reaches the river-bed again, where massive greenish grey and reddish outcrops of lava-flows up to 60 feet in thickness are found. The strike is here north-14°-west and there is little doubt that the quartzites are identical with those found below Riu. The river flows straight along the strike, and the water is confined in a narrow, and very deep rock-bound channel. Some of the traps are amygdaloidal, and are interbedded in one place with a thick bed of shale which has been hardened by thermal metamorphism, become light brown in colour, and developed a new jointing

perpendicular to the bedding planes. The junction of the flow with the shale can be seen and illustrates at a glance the contemporaneous nature of the former.

Sections at Geku crossing.

At Geku crossing, a little further up stream the rocks on both banks of the river strike north and south and dip west at 45°, though there is still a good deal of local variation. Hard, fine-grained, greyish-black sandstones and quartzites in well developed layers, often with joints and bedding planes marked by quartz infiltrations, are here interbedded with greyish, indurated slates and reddish, greenish and mottled red and green volcanic ashes. The latter sometimes graduate into thin shales of a yellow colour with irregular purple blotches. Between the Geku crossing and the junction of the Mabung stream, on which the important Minyong village of Riga is situated, there are good exposures of these rocks. After crossing the variegated volcanic ashes, hard, greyish-black sandstones are met with, which in places are interbedded with hardened slaty bands; the original shaly structure is however quite evident. Large rounded boulders of traps of various sorts, and of agglomerates containing amygdaloidal pebbles are very common in the bed of the river. The greater part of the detritus brought down by the Mabung is also of volcanic origin. On the north bank of this small stream, greyish-green shales with well marked joints and bedding-planes can be seen, and on the opposite bank of the Dihong dark sandstones crop out. In places the latter contain layers of shale with very numerous clay-ironstone nodules. At the mouth of the Mabung the dip is north-north-east at 64°, but the rapid changes in dip and strike are very peculiar.

Petrology of the Abor Traps.

Almost all the specimens collected consist of greyish, greenish or reddish basaltic traps, often very amygdaloidal, but sometimes quite solid and showing signs of crushing and mechanical deformation. The ground-mass is always very much decomposed and imperfectly crystallized, containing small augite and magnetite granules. Fairly fresh lath-shaped felspars often occur and there are also large tabular forms,—once felspar phenocrysts. Remnants of ophitic and micro-ophitic structure are generally visible. In every slide examined green or greenish yellow patches of palagonite occur, usually in rounded masses, but sometimes of a more irregular

shape. These appear to represent the residual glassy portions of the magma filling in irregular interspaces between the crystallized portions. Extensive decomposition into chlorite, occurring in perfect spherical amygdules, takes place in some slides. There is also a large amount of chalcedony present which appears to be derived from the felspars.

In a slide from the Dihong bed at Rotung stockade colourless prisms of epidote occur in a quartz geode, the crystals frequently radiating from the walls, though in some cases a layer of quartz intervenes. In a few cases an edge of a large geode is continued across the slide as a distinct fissure filled with quartz or with quartz and palagonite, finally dying out in the ground-mass. In other cases the amygdules contain an outer layer of palagonite in addition to epidote and quartz. The specific gravities of the traps range from 2·826 to 2·958. I am indebted to Mr. H. S. Bion, Curator of the Geological Museum and Laboratory, for examining the rocks for me whilst I was in the field, and to my colleagues Messrs. C. S. Fox and R. C. Burton for looking over the slides on my return.

These rocks show great resemblances to the palagonite-bearing traps described by C. S. Middlemiss from the Rajmahal Hills,[1] which in their general method of occurrence are also very similar to those of the Abor Volcanic Series. This will be at once noticed from the following description by Medlicott and Blanford :—

> "In its typical locality the Rajmahal group of the Rajmahal series consists of a succession of basaltic lava-flows or traps with interstratifications of shale and sandstone. The sedimentary bands are held to have been deposited in the intervals of time which elapsed between the volcanic outbursts, by the circumstance that the different bands of shale and sandstone differ from each other in mineral character, and also that the upper surface of the shaly beds has sometimes been hardened and altered by the contact of the overlying basalt, whilst the lower surface is never affected. The sedimentary bands are chiefly composed of hard white and grey shale, carbonaceous shale, white and grey sandstone, and hard quartzose grit."[2]

[1] C. S. Middlemiss: "On some Palagonite-bearing traps of the Rajmahal Hills and Deccan," *Rec., Geol. Surv. Ind.*, Vol. XXII, pp. 226-235.

[2] *Manual of the Geology of India*, 2nd edn. (1893), p. 175.

Metamorphic Rocks.

As considerable differences of opinion exist regarding the nomenclature and age of the metamorphic rocks of the Eastern Himalaya, I propose to summarise here the views of various authors on them :—

F. R. Mallet working in the Darjeeling and Buxar Duars areas proposed the names Daling and Baxa series for the rock systems which lie between the Gondwanas and the true crystalline strata forming the core of the Himalaya. He was inclined to believe that the Dalings were younger than the Gondwanas, and was unable to make up his mind about the Baxas.[1]

R. D. Oldham gives the following concise description of the two series :—" They consist of light green, slightly greasy, slates. sometimes, interbanded with a dark greenish grey kind, passing insensibly into ordinary clay slates and more or less earthy or silvery according to the degree of alteration they have undergone. There are also bands of quartzite and quartz flags, occasionally some hornblende schist, sometimes slightly calcareous and passing into an impure dolomite containing crystals of actinolite. This is, however, a rare and exceptional rock, the most prominent lithological distinctions between these and the succeeding Baxa series being the almost complete absence of lime and the rarity of the brilliantly-coloured alternations of slates.'' He then goes on to say that " the opinion now prevalent is that of two contiguous series of beds the one which exhibits the greatest degree of metamorphism is *primâ facie* the older," and later refers to that common feature of Himalayan sections in which the newer beds apparently dip under older ones. While the almost universal prevalence of overfolding and reversed faulting in the outer Himalaya is admitted, the former statement regarding the degree of metamorphism cannot be accepted in its entirety.[2]

Colonel H. H. Godwin-Austen records the occurrence of metamorphic rocks in the Daphla Hills and looked upon them as probably representing Mallet's Daling Series, but made no suggestion as to their age.[3]

T. D. LaTouche working in the Aka country, some 60 miles to the west of Godwin-Austen's traverse, met with micaceous slaty

[1] F. R. Mallet : *loc. cit.*, pp. 38 and 44.
[2] *Manual of the Geology of India*, 2nd edn. (1893), p. 76.
[3] Godwin-Austen : *loc. cit.*, p. 39.

schists and silvery greenish mica schists sometimes slightly talcose, which he regarded as the equivalent of the Daling slates and schists of Sikkim, but stated that he was unable to throw any light upon the question as to which of these series is the older.[1]

P. N. Bose states that in Sikkim phyllites form the predominant rocks of the Daling group, passing sometimes into silvery mica schists, dark clay slates with thick quartzite bands; gritstone, impure siliceous limestone and highly carbonaceous shales also occur. He considers that they represent the slate series of the north-west Himalaya, and C. L. Griesbach's Haimanta system of the Central Himalaya.[2]

J. M. Maclaren found metamorphic rocks *in situ* at the Brahmakund, as quartz schists, and 6 or 7 miles north-west of the Kund, as garnet and amphibolite schists. The quartzites, which form a very large percentage of the rock debris in the river-bed at the Brahmakhund, he regarded as not improbably representing a portion of the Purana system, and small quantities of a schistose slate or phyllite "represent in all probability the Daling series of Purana rocks first described by Mallet in Sikkim."[3]

G. E. Pilgrim in a paper on the geology of parts of Bhutan states that there can be little doubt that both Dalings and Baxas belong to the Purana group. The Dalings he describes as "grey or greenish schists sometimes carbonaceous passing up into quartzites, and the Baxas as mainly dolomites and quartzites with flaggy quartzites and quartz schists." This author believes that the Baxas are younger than the Dalings and that both series were deposited along this part of the sub-Himalaya, but ancient faulting and subsequent denudation has entirely removed one or other of them from over large areas. He also feels inclined to regard these beds as the equivalents of the dolomites and slates of Naini Tal, but recognises the difficulty of correlating strata at a great distance from each other on mere lithological resemblances.[4]

L. L. Fermor expresses the verbal opinion, based on the similarity in composition of the Sikkim Dalings and the Dharwars of the Central Provinces, and their respective relationships to the

[1] T. D. LaTouche: *loc. cit.*, p. 123.
[2] P. N. Bose: "Geology and Mineral Resources of Sikkim," *Rec., Geol. Surv. Ind.*, Vol. XXIV, pp. 222-223.
[3] J. M. Maclaren: *loc. cit.*, pp. 182-183.
[4] G. E. Pilgrim: *loc. cit.*, pp. 22-30.

gneissose rocks of the two areas, that the two systems are of the same age.

H. H. Hayden, after referring to the facts that both the Dalings and the Baxas appear to overlie the crushed representatives of the Damuda and other outer series of the sub-Himalayan zone,—a position brought about by recumbent folds and reversed faults, and to the progressive metamorphism of each higher member, considers that we may safely assume that the apparent sequence is the reverse of the true one, and that the Daling is in reality older than the Baxa series and the latter older than the Damudas. Moreover, both series are referred to the pre-Cambrian systems of the Indian Peninsula of which they probably constitute merely an outlying portion, the Dalings resembling in some respects the Dharwars, and the Baxa series finding its nearest relatives amongst the members of the Cuddapah system.[1]

It is impossible to come nearer the truth than this in the absence of further evidence. My hurried observations made on the metamorphic strata exposed in the inner ranges of the Abor hills are not complete enough to permit of any extended sub-dividing, and I shall therefore only put on record the sections passed over without commenting on the probable ages of the beds themselves.

The Metamorphic Series around Pagin and Yekshi.[2]

These two villages are situated on the west bank of the Dihong to the north of Yambung, and the area around them presents immense difficulties to the geologist owing to the thick soil-cap, the almost impenetrable grass growths and the thick forests. It is certain that the Abor Volcanic Series continues for two miles beyond Yambung, but beyond this all exposures are hidden. Small pieces of quartzite, slate and greyish fine-grained phyllite are found on the Abor track, and as the harder strata of the volcanic series are left behind the character of the country changes, the narrow valley opening out and the higher spurs becoming flatter and rounder. Ascents were made on to the high ground to the west of Pangin and from there extensive views of a lofty range to the north of the Chuliakatta Mishmi country were obtained, but during these journeys not a single rock outcrop was discovered.

The main Abor track from the south crosses the Dihong by a long tubular cane bridge between Yekshi and Komsing. At this

[1] Burrard and Hayden: "Geography and Geology of the Himalaya Mountains and Tibet," pt. IV, pp. 228-229.

[2] Spelt Yekshing on the map.

point fine-grained sericitic schists with thin quartz veins strike north-20°-east and dip indifferently at high angles. Opposite Yekshi there is a development of a brecciated limestone and streams flowing from this deposit calcareous tufa. One mile downstream from the bridge, sections of highly contorted slates, phyllites and thin bands of hard brecciated limestones strike north-20°-east. The only rocks *in situ* around the village of Komsing are highly contorted purple slates, but pieces of slaty dolomitic limestone are often found about the "*jhumed*" hillsides.

The Metamorphic Series between Geku and Paling.

In Geku village there are outcrops of purple, bluish-grey and yellowish slates with red blotches, whose general appearance recalled to my mind the Chaung Magyi slates of the Northern Shan States. They are strongly cleaved, the planes running east-north-east and west-south-west, while the dip is high in both directions. In the small stream beyond the village, boulders of amygdaloidal traps are seen, indicating a junction of the metamorphic rocks with the Abor Volcanic Series in the near vicinity. Similar slates are found at long intervals between Geku and Komkar and the great variation in the dip and strike of the different exposures indicates considerable surface displacement. Purple slates and quartzites continue from Komkar to the Karpin stream, and an outcrop on the top of the pass from which the wider part of the valley towards Shimong is first seen, gives a north-west south-east strike and a dip at 45° to the north-east. The road here crosses along the tops of steep "*jhums*" and winds around the heads of narrow, deep valleys formed by the smaller tributaries of the Dihong. Near Shimong itself, flaggy quartzites crop out and are used hereabouts to pave the road. Between Shimong and Puging there is but little variation in the lithological character of the rocks met with, and purple and dark grey slates with well marked beds of hard quartzite make up the succession. Exposures are only obtained in the stream-beds, and elsewhere a thick reddish soil-cap masks all outcrops.

From a "*jhum*" two miles to the south of Gette a well marked plateau about 100 feet above the present level of the Dihong is seen, the formation on the opposite bank though clearly visible is not so well marked. Looking down stream from this point, the steep, forest-clad slopes of the narrow valley of the Dihong below Shimong are very striking, marking as they do the position of the

harder igneous rocks which come in there. Just below this again there is a further broadening out on a smaller scale, caused by the ash and shale bands outcropping below Geku, but to the south of this the river enters the narrowest part of its valley formed by the main masses of the volcanic series.

As Puging is reached the metamorphism becomes stronger and slates give place to phyllites with very fine-grained mica schists. Extremely crushed bands of reddish and greenish amygdaloidal traps are seen in a few places, but it is impossible to say whether these are connected with the Abor Volcanic Series or belong to the metamorphic rocks proper. From the high "*jhums*" 3,000 feet above the Dihong at Puging, the course of the river to the north-west is seen to become again very gorge-like and narrow, bounded in the far distance by a magnificent snowy range, while towards the north-east there is another but less lofty snowy range in which the upturned edges of contorted strata are clearly visible.

Beyond Puging the general direction of the track continues to the north to avoid two large bends in the course of the Dihong itself. There is a very steep ascent at first, which further on becomes easier when greenish grey chloritic slates, hard sandy grit bands, and very metamorphosed banded purple and green slates crop out. These slates contain much quartz which often has a cellular structure.

Dolomite Series.

The watershed is reached at about 4,000 feet, after which there is an exceedingly precipitous descent to the Sisi river over metamorphosed and very brecciated, dark bluish-grey dolomites in thick beds, with an occasional sandy layer. The strike at the bottom is north-west south-east with a dip at 80° to the south-west. The valley of the Sisi is only 50 yards across, but it has a flood level of 35 feet and is full of large, water-worn schistose and gneissic boulders, a garnetiferous mica schist being the commonest rock. These dolomites continue to a point half way between the Sisi river and the next Abor village of Rikor, where they are followed by fissile paper schists with numerous long lenticles of quartz. Good exposures of these rocks are obtained in the bed of the Siri river where they strike north-west south-east and have a vertical dip. On the long spur below Rikor, boulders of a dark mica schist and of a fine-grained augen gneiss were found, but these are probably water-borne. Fine-grained dark biotite schists crop out one mile below Rikor village

and are followed by quartzite bands which soon give place to the metamorphosed dolomitic series again, the strike of which is variable though usually east-north-east west-south-west with a vertical dip. Flaggy dolomitic beds are common, and the calcium carbonate washed out by small streams is re-deposited in round concretions, which are seen along the path in many places. The last outcrop of dolomite is found at a point half way up the steep ascent to the village of Paling from the Dihong, and is followed by a series of quartzites, sericitic schists and micaceous phyllites, sometimes entirely composed of a silvery white mica. Small drawn-out pieces of quartz are common in these rocks which ½ mile to the north of Paling strike east and west and dip north at 35°.

Mica-Schist Series.

Somewhere near the point where the road leaves the Dihong after descending the steep path from the little plateau on which Paling is built, the metamorphic rocks are followed by true mica schists and associated crystalline limestones with a schistose structure. These constantly strike north-east south-west and dip at 85° to 90° to the north-west. Finely grained and well banded biotite and muscovite schists with rarely a thin development of quartz or actinolite schist, are found to the south of Singing, the highest point up the river reached by the Dihong Exploration Column. As these rocks appear to constitute a different lithological group to the ones met with before, I have placed them together under the heading Mica-Schist Series.

To account for the repetition of similar groups of rocks, especially in the volcanic and metamorphic series, as the Dihong valley is traversed from south to north, the existence of closely packed, sinuous folds, often overfolded and overthrust, but having a general north-east south-west trend, is suggested. The true structure will, however, only be brought to light when more detailed surveys of the Abor hills and other surrounding regions have been made.

Economic Geology.

Gold.

I obtained gold from the gravel beach in the bed of the Brahmaputra at Kobo, but only in insignificant quantities representing less than ½ grain gold per ton. J. M. Maclaren has already prospected the Dihong from the point

where it enters the Brahmaputra to Pasighat, and found gold in small quantities in all the gravels he examined. With regard to the gravels at Pasighat itself, he writes: "For the first time in Assam a considerable residue of black sand failed to yield colours of gold."[1] I have to confirm this observation, being quite unable to obtain any gold from these gravels.

Further into the Abor hills the current of the river does not permit of the deposition of gold, and only very rarely of gravel banks of any kind. Pan tests were made on the material dug out of pot-holes which are under the river during the rains, but no trace of gold was found in them. There are no banks of gravel suitable for dredging in any part of the river known to me, and on general grounds I can hold out little encouragement for gold prospecting higher up.

Coal.

In the body of this report I have already drawn attention to the occurrence of coal in strata of two ages in the outer Abor hills. Sandstones of Siwalik age in the neighbourhood of Pasighat often contain nests of bright lignite of good quality. The deposits, however, are not continuous and the fragments of lignite merely represent the remains of water-logged drift-wood carried down to the sandstones during their formation. This occurrence is of no economic value whatever.

Patches of coal are also found in the Gondwana rocks of the Sirpo valley. Though once continuous seams, they have now assumed the form of lenticular patches owing to the intense crushing to which they have been subjected. This too has made the coal itself friable and dusty, so that it falls to powder when handled. The quality of the material is very poor, the percentage of ash being unusually high and the volatile matter low. Even if the seams were thicker and continuous, and cheap transport to the plains of Assam available, the cost of working in these rocks would be enormous and such Gondwana coal as I saw in the Abor hills is never likely to be mined as a profitable undertaking. I am informed by Captain O'Neill, I.M.S., that coal seams outcrop is the Aieng country on the east of the Dihong, but no opportunity occurred for a traverse in that direction. It is highly probable that these seams are of the same age as those discovered in the Sirpo valley and there is no reason to suppose that their composition is any better. Captain Sir George Duff

[1] J. M. Maclaren: "Gold in Assam," *Rec., Geol. Surv. Ind.*, Vol. XXXI, p. 224.

Sutherland Dunbar Bart., also reported the existence of coal in the Galong Abor country further to the west. This area, however, was quite beyond the routes of the columns to which I was attached.

Iron-ores.

In the bed of the Dihong at the Geku crossing, thin bands of shale are found which contain numerous nodules of clay-ironstone of good appearance. So numerous do these sometimes become that in places it might be possible to work the rock as an iron ore. The quantity available, however, cannot be large. I have given an account of the associated rocks in an earlier paragraph and there is no need to repeat the description here.

Copper.

The copper and brass used by the Abors in the manufacture of articles of personal adornment, such as bracelets, come either from the bazaars of the plains of Assam or, especially in the northern part of the Dihong valley amongst the Shimong and Janbo tribes, from Tibet. They appear to be unacquainted with the extraction of any of the metals from their ores, and the only metallurgical operations I saw or heard of in the country, were those connected with the primitive trade of the blacksmith and coppersmith, and the manufacture of knives or spears, and bracelets or petty trinkets respectively. The exigencies of the march prevented me from making as complete an examination of the metamorphic strata which I passed over as I should have liked to do, but in the bed of the Sisi river I saw rolled fragments of rock containing specks of chalcopyrite, and I would draw the attention of future prospectors to the watershed of this tributary of the Dihong as one which is worth looking over for copper ores.

Marble.

Beds of white, coarsely crystalline limestone or marble are associated with mica schists in the neighbourhood of Singing. In appearance they recalled to my mind the saccharoidal marbles of Sagaing in Upper Burma. I am unable to give any estimate as to the available quantities.

Earthenware Clays.

The Abors sometimes manufacture coarse earthenware pottery, but they appear to use any clay which happens to be found in the immediate vicinity. Some of the light red tenacious clays formed from the disintegration of the rocks of the Abor volcanic series would make the best kind of material for this industry.

A TRAVERSE ACROSS THE NAGA HILLS OF ASSAM FROM DIMAPUR TO THE NEIGHBOURHOOD OF SARAMETI PEAK. BY E. H. PASCOE, M.A. (*Cantab.*), B.SC. (*Lond.*), F.G.S., *Assistant Superintendent, Geological Survey of India.* (With Plates 28 to 32.)

Preliminary.

The following sketch is the result of my deputation to accompany a punitive column in charge of Lieutenant-Colonel A. E. Woods, Deputy Commissioner of the Naga Hills District, and Major C. Bliss, to a village some nine miles north-north-east of Sarameti, the highest peak (12,557 feet) in the Arakan Yoma. This village, known as Makwari or Makuri on the Burma side, but as Dzulechili or Gulachili by its own inhabitants, lies in the unadministered territory between the Naga Hills and Upper Chindwin Districts, in a region hitherto entirely unexplored. The column left Kohima at the beginning of January and returned the middle of February 1911. The length of the traverse in a direct line between Dimapur (Manipur Road Railway Station) and Dzulechili is 80 miles.

Maps.

Covering the less interesting part of the route $\frac{1}{2}$ inch maps were available, but east of the Tepe and Tuzu Rivers there was nothing but the conjectured topography published in the Indian Atlas (1 inch to 4 miles, Sheet 130, S.E.), much of which proved to be fundamentally incorrect. By the courtesy of Captain V. R. Cotter, Assistant Director of Surveys, Assam, I was able to locate the features of geological interest on a tracing of the map he was constructing, by means of geographical notes made *en route* and by pedometer readings on the march, kindly supplied by Captain A. L. Molesworth. This part of the geological map, therefore, can only be approximately correct (see Pl. 32).

Previous work.

A report and geological map by Mr. R. D. Oldham on the geology of parts of Manipur and the Naga Hills. (*Mem. Geo. Sur. of Ind.*, Vol. XIX, Article 4) deals with country immediately around Kohima, and, further south, includes a long section from Lakhipur in Kachar

through Manipur to the Chindwin River in Burma. A paper and geological map by Mr. Hayden (*Rec. Geol. Sur. of Ind.*, Vol. XL, page 283) are the result of a more extensive survey from Kohima north-eastwards as far as Jaipur.[1]

Introduction.

Tertiary strata representing in all probability the Tipam series are exposed on the west, and are succeeded eastwards by the argillaceous Disang series to which the greater part of the rocks passed over belong; beyond these are beds which I have classed as doubtful "Axials." The structure appears to be that of a series of tightly packed, isoclinal, sinuous, rising and pitching folds, with a general north-north-east to south-south-west trend, and more or less overfolded towards the west. The strike follows the hill ranges, occasionally swinging round to north and south, or to north-east and south-west. Vertical strata are common but a dip of about 45° is perhaps commoner still: in some places the dip is quite gentle and may remain so for some distance. In this traverse there was a tendency for the rocks to dip towards the centre of a ridge, the valleys coinciding with anticlinal folds; there are good examples of the latter in the Tuzu and Tepe Rivers.

Physical Features, Flora and Soil.

The country is mountainous: ridge after ridge, rising commonly 3,000—4,000 feet above the intervening, steep, well-watered valleys, are crossed on the way eastwards and become more uniformly higher until the Sarameti range is reached, which contains several peaks from 9,000 to 12,000 feet high, lightly snow-capped during cold weather. The watershed between the Brahmaputra and Chindwin valleys occurs much further to the west, coinciding with the Kopamedza or Nummuh range, nearer the centre of the Disang outcrop. The tops of many of the ridges give rise to a peculiarly level sky-line, a good example being seen at Sakhaboma, a day's march east of Kohima. The jungle is very dense in places and the undergrowth usually sufficient to prevent progress. The chief obstacle to survey work in the unadministered country is the scarcity of paths and the frequently impassable state of those

[1] See also:—The coal of Assam—H. B. Medlicott (*Mem., Geol. Sur. Ind.*, vol. IV, Art. 3); The Geology of Pegu—Wm. Theobald (*Ibid.*, vol. X, Art. 3); The Coalfields of the Naga Hills bordering the Lakhimpur and Sibsagar Districts, Assam—F. R. Mallet (*Ibid.*, vol. XII, Art. 2); The Geology of Upper Assam—J. M. Maclaren (*Rec., Geol. Sur. Ind.*, vol. XXXI, p. 179); The Jaipur and Nazira Coalfields, Upper Assam—R. R. Simpson (*Ibid.*, vol. XXXIV, p. 199).

that exist; there is scarcely any communication between neighbouring villages, which are, as often as not, at war with one another. Oaks and chestnuts abound: forests of pine-trees, usually accompanied by small, stemless date-palms, occur somewhat capriciously on both the higher and lower slopes. On the ridge above Puchimi flourishes a tree rhododendron, probably the Himalayan *Rh. arboreum.* Near villages are found bamboos of enormous size, much prized by the Nagas; many kinds of ferns and orchids are to be seen everywhere. The Disang shales produce a fairly rich soil and the terrace system of rice cultivation has been brought to a high standard. A certain amount of cotton is grown and a species of millet known as "Job's Tears," the staple food of the country, is raised on "jhum" land, *i.e.*, clearings which after cultivation for a couple of seasons are allowed to lie fallow for seven or eight years. The dense jungle, such as that found on Nummuh, produces a rich black mould; near villages this is used for raising small crops of indigo employed for dyeing blankets. In more open places a red ferruginous soil is forming.

The Tipam rocks.

The double traverse will be described in the order of the outward journey, from west to east. The alluvium of the Dhansiri River ends below the Samaguting ridge where hills of Tertiary rocks commence somewhat abruptly. These Tertiary rocks belong apparently to the Tipam series, and extend to about a mile west of Kadiuba peak. Sandstone predominates, grey-brown or olive in colour, sometimes massive, sometimes fairly well-bedded, varying from a fine to moderately coarse texture. A comparatively soft iron-stained sand-rock, reminding one of the Burmese Irrawadi sandstone, is frequently seen. In this local patches of ferruginous matter sometimes occur, similar to those which, in the Burma series, mark the resting places of fossilized tree-trunks; no fossil wood, however, was found, and it is to be noticed that Mr. Oldham makes no mention of having observed this substance during his survey. Ripple-marking, current-bedding and local unconformity are not uncommon. Small streaks and patches of lignite are occasionally observable, the latter sometimes associated with iron-staining and yellow ochre, and evidently the remains of a branch of wood. Grey or grey-blue shales, sometimes micaceous, and blue clunchy clay, play a secondary part, but beds of alternating sandstone and clay are common. No fossils were found during this traverse, but some

badly preserved pelecypods were discovered by Mr. Oldham in the Diphu River gorge, presumably near Samaguting.[1]

Disang-Tipam boundary.

This side of the 23rd milestone from Dimapur the last exposure of white, soft, Tipam sand-rock is seen: beyond this shale and sandstone of a different character appear, which belong to the Disang series.[2] The junction has been found by Mr. Hayden, further north, to be a reversed fault.[3] I could find no occurrences of either "Coal Measures" or Tipam sandstone south-east of this fault.

Disang series.

East of the boundary the first beds met with are dark carbonaceous shales with thin bands of fine sandstone or massive shale, but further up the road thick massive sandstone with thin shale partings here and there, form the range containing the peak of Kadiuba: these beds show considerable contortion. The same sandstone but in greater thickness is seen again in the neighbourhood of Karuphima village and culminates in the peak of Siwenuchika (7,379 feet). Between these two exposures the beds consist of the usual shales. The massive sandstone is no doubt Mallet's "Naogaon Sandstone" forming the top of the Disangs; its reduplication may be a natural sequence or a result of minor thrusting or folding. Further eastwards extends for many miles a monotonous sequence of argillaceous strata, varied here and there by hard bands of fine sandstone, which however is never very thick and has the appearance of being merely a more massive, impure variety of the shales. A concretionary texture on a small scale was observed three or four miles east of Kohima. A harder type of bed, weathering like a limestone but containing no calcareous matter, is seen east of the villages of Phekrokejima and Losami, and is also found on the top of Nummuh peak. In the more western parts the argillaceous beds consist of shales, blue or grey in colour, the layers of which are often characterized by a peculiar crinkled surface; the harder material occurs in thin layers or lenticles. Iron pyrites is sometimes seen in the shales, and carbonaceous matter is common. Passing eastwards metamorphism increases and a transition from shales

[1] *Mem., Geol. Sur. Ind.*, vol. XIX, Art. 4, p. 12.

[2] Mr. Oldham drew the boundary a little further to the east, but sections in the new road, I think, now make clear its position, which moreover lies on the line of strike of the boundary in the Barak valley to the south, and according to Mr. Hayden's map, of the boundary west of Wokha to the north. See maps—*Mem.*, *Geol. Sur. Ind.*, XIX, Art. 4, and *Rec.* XL, p. 144.

[3] *Rec., Geol. Sur. Ind.*, vol. XL, p. 283.

to hard glossy slates takes place; these are usually dark blue in colour, weathering to a greenish or greyish white. East of Cheswejuma thin veins of quartz become more noticeable, and reach thicknesses of three or four feet east of Chomi: near the junction of the Tepe with the Tuzu, and elsewhere, quartz is seen in eye-shaped lenticles in the slate. East of the Tuzu, in the vicinity of the serpentine, the sediments become more foliated and schistose; foliated phyllite is common and a few pieces of a banded crumpled schist were picked up. These phyllites are frequently talcose or chloritic, green in colour and soapy to the touch. Carbonaceous matter in the form of graphite occurs in connection with some of the more metamorphosed rocks and also with the quartz veins. A brine and sulphur spring occurs in the small stream north of Phozami; the former is not uncommon in the Disangs.

Serpentine.

It was difficult on a rapid march, without sections and without a map, to determine the correct sequence of rocks in the neighbourhood of the serpentine, but the latter corresponds in position to the band mapped by Mr. R. D. Oldham in Manipur. Small pieces of it were picked up in the Lanier River, so that it certainly extends up part of this valley: large fragments of serpentine and gabbro were seen in two of the branches of the large tributary of the Tepe immediately south-west of Chimi, so that there must be igneous exposures west of the ridge here. Between Puchimi and Karami the serpentine cropped out in the form of a line of conical crag-crowned hills with scant vegetation[1]; the rock consists of a confused mass of both massive and fibrous serpentine. In other places the serpentine with its associated chrysotile and chlorite has to a large extent become schistose and is with difficulty distinguishable from the metamorphosed sediments among which it occurs.

Petrology of the serpentine rocks.

Boulders of the following types, from which the derivation of the serpentine may be deduced, were collected in the Tuzu River and some of its tributaries :—

(i) A hornblende-enstatite-olivine-gabbro. This is a coarse-textured, mottled dark green and white rock, which under the microscope (see pl. 28, fig. 1 and 2) is seen to consist of saussuritised felspar, green pleochroic hornblende with the characteristic double cleavage, enstatite ("bronzite"),

[1] *Cf. Mem., Geol. Sur. Ind.*, vol. XIX, Art. 4, p. 9.

augite intergrown with both the amphibole and the rhombic pyroxene, and olivine. The augite is considerably cracked, the cracks being filled with calcite and other decomposition products. Diallage striation is occasionally seen and also a regular arrangement of lozenge-shaped inclusions; it is usually either intergrown with or bordered by hornblende, of which some at least is secondary. The rhombic pyroxene is light yellowish in colour and slightly pleochroic, altering here and there to bastite; it has an extinction angle of as much as 5-6°. The slide shows a little olivine in two places, changing into serpentine with the usual mesh-structure. Iron ores are practically absent. This rock would pass readily into a diorite, norite or peridotite; it is not unlike a rock described by Mr. J. F. Kemp, from near Elizabethstown, Adirondacks, but magnetite is absent in the Naga type.[1]

(*ii*) A diallage-gabbro. This rock is milky white spotted with dark green pyroxene. The bulk of it consists of felspar which, though much decomposed, shows distinct twin-lamellæ which are very frequently wedge-shaped: it appears to be a medium labradorite (see pl. 29, fig. 1). The monoclinic pyroxene shows the striation of both diallage and salite, and is surrounded by a rim of clear light green, pleochroic, secondary hornblende, which, under a high power is seen to penetrate the diallage "prisms" or "columns." Irregular pieces of this uralitic hornblende are scattered about the slide and frequently contain small kernels of diallage.

(*iii*) A serpentinized Lherzolite or altered picotite-enstatite-diallage-peridotite. This is a black rock in which lustrous green crystals of diallage can be observed. Felspar is absent. The bulk of the rock consists of serpentine in the meshes of which grains of undecomposed olivine can be seen (pl. 29, fig. 2, pl. 30 and pl. 31, fig. 1); some of the serpentine shows "knitted" structure and appears to have been derived from pyroxene. Rhombic pyroxene is plentiful, is not perceptibly pleochroic, shows a fairly distinct cleavage, and has a considerable extinction angle;

[1] *Rep. U. S. Geol. Sur.*, XIX, (1899), pt. 3, pp. 406-407, pl. LX, fig. A.

other signs of bending or strain are frequent, and alteration to bastite is common. The diallage, which shows "columnar" or "prismatic" structure, is subordinate to the rhombic pyroxene. A spinellid mineral occurs in very irregular, cracked fragments, the cracks being filled with black iron ore, often leaving the rest of the crystal a clear greenish brown; most of this is picotite but some of the darker varieties may be nearer chromite. A border of clear granular feebly-birefringent material always accompanies this mineral. Dr. Fermor called my attention to the resemblance between this rock and De la Méthérie's 'Lherzolite,' and a careful comparison with descriptions of the Pyrenees rock more than justifies the present use of the term, assuming that nearly all the serpentine has been derived from olivine. Through this alteration the specific gravity of the Naga Hills specimen is 2·809 instead of 3·280.[1] The same rock occurs in Haute-Loire, and very similar types in Piedmont and other parts of Italy, in Spain, the Hebrides, the Tirol, California, and in Ladak.[2] In the latter locality serpentinization has brought the specific gravity down to 2·85. Lherzolite was found by Mr. J. P. Johnson in South Africa, forming the more resistant portions of a rock which, with eclogite, is thought to form probably the real home of the diamond.[3]

(*iv*) This is a dark green serpentine, veined with calcite and derived from a spinellid-peridotite. Besides green serpentine the slide contains ragged pieces of pyroxene, chlorite, and numerous fragments of picotite (pl. 31, fig. 2). Most of the latter are small, but a few are large and much cracked; all have the translucent, almost isotropic border.

(*v*) This is an altered porphyritic rock consisting of a dark reddish matrix in which are embedded numerous large greenish white felspars. The felspars show idiomorphic outlines and twin-lamellation, while the groundmass is andesitic in nature, consisting of innumerable felted felspar microlites and much iron ore.

[1] Zirkel: Petrographie, III, p. 132.
[2] *Mem., Geol. Sur. Ind.*, XXXI, pt. 3, (1901).
[3] *Trans. Geol. Soc., S. Africa,* X, p. 113.

One of the most important members of the sedimentary deposits is a conglomerate, sometimes passing into a coarse, pebbly sandstone forming a lofty N. E.—S.W., ridge: east of Chimi it is of great thickness. Among its pebbles are fragments of serpentine. Streams draining the ridge containing the conglomerate and serpentine, are noticeably well-supplied with water. A little west of the conglomerate occurs a thick massive green felspathic grit or sandstone, varying in composition but containing angular quartz and felspar grains, chlorite and serpentine, and fragments of pyroxene and olivine. This and the conglomerate are evidently of later age than at least some of the serpentine, which must have been intruded prior to the deposition of the greater part or nearly all of the Disangs.

Conglomerate.

The beds east of the conglomerate differ only in the greater degree of metamorphism to which they have been subjected from those on the west, most of the beds having taken on a foliated habit and harder texture; slates of the ordinary Disang type are, however, not rare and are associated with quartz in the usual way. They contain small intrusions of serpentine, much of which is the chrysotile variety; the serpentine has to a large extent become schistose and is with difficulty distinguishable from the metamorphosed sediments among which it occurs.

Makwari beds.

The complete absence of limestone between the Tipam-Disang boundary west of Kohima and the Sarameti ridge is notable; the only calcareous matter found was a little tufa in one of the stream-beds. There is therefore no representative of the limestone found around Akral in Manipur and considered as probably belonging to Theobald's Mai or Cretaceous group. Mr. Hayden has commented upon the provisional correlation of the Disangs with Theobald's Axial beds in Burma (which are known to include upper Trias) and expressed his inclination to class them rather with the Negraïs beds of the same writer, as Mallet was originally inclined to do. Both the terms 'Negraïs' and 'Axials' are ill-defined, and should be looked upon as provisional. In this traverse I think it probable that the Disangs would have been classed by Theobald as Negraïs, and the Makwari beds or beds east of the conglomerate as Axials. Besides the greater lithological resemblance between the Disangs and the Negraïs as described, than between the same series and the

Correlation of the Disangs.

Axials, and besides the occurrence of brine springs, so characteristic of the Burmese Negraïs, in the Disangs west of the serpentine, there are two important facts bearing on this question: (*i*) the occurrence of a thick and extensive conglomerate at what has the appearance of being the base of the Disangs, and (*ii*) the position of the serpentine which in Burma lies within or along the eastern boundary of the Axial beds.[1] With regard to the latter point it may be mentioned that the western boundary of the Axial beds in Burma was not surveyed and *may* be associated with serpentine; the three bosses in a line, mapped by Theobald at the pointed southern extremity of the Axial outcrop, are rather suggestive of this. This correlation is in accord with the opinion of Mr. Tipper that the serpentine in the Andamans, which lie upon the same tectonic axis as the Naga Hills, is probably of Upper Cretaceous age, like that of Baluchistan and other parts of India[2]; fragments and pebbles of serpentine were found in the Eocene conglomerates of the Andamans. The presence of the conglomerate is practically the only reason for making two divisions of the rocks of the Naga Hills, however, and there is no reliable evidence that the Makwari beds are older than the beds west of the conglomerate. It is interesting to note that, some 30 miles east of Kabul in Afghanistan, Mr. Hayden found a band of serpentine intruded between beds strongly resembling the Himalayan Trias (Khingil Series) and the Tertiaries (Siwaliks).[3]

Post-Tertiary deposits.

With reference to the post-Tertiary deposits, my conclusions agree with those of Mr. Oldham who preferred to regard them as river terraces of gravel rather than moraine material. It is true that some of the valley-heads are not unlike the "cwms" generally attributed to ice-action, and the upper parts of the valley-flanks often show rounded shoulders and irregular, scooped surfaces; this may have been the reason for Major Godwin-Austen's view of glaciation, but it seems to be the natural weathering action of a moist climate upon a comparatively homogeneous mass of steeply-dipping shale or slate. The terraces moreover are flat-topped, sloping

[1] See map of Pegu, *Mem., Geol. Sur. Ind.*, X, Art. 3.
Theobald originally included the Negraïs beds with his Axial system, using the latter term for the whole of the altered rocks forming the main Arakan Range. See *Rec., Geol. Sur. Ind.*, IV, p. 33.

[2] *Mem., Geol. Surv. Ind.*, vol., XXXV, pt. 4, p. 11.

[3] *Op-cit.*, XXXIX, Art. 1, p. 21, and map, pl. 20.

gently down stream; that of the stream north of Mima village, flowing into the Mizir River (see map facing p. 14, *Mem., Geol. Sur. Ind.*, vol. XIX, Art. 4) is extremely flat, and due in my opinion to the beheading of this stream by what is now the main Mizir stream, the broad river-bed thus left high and dry being subsequently dissected by the cutting back of the present Mima tributary. Terraces flanked every stream of any size passed over in this traverse, rising frequently to 200 feet above the water which is now cutting its way down into the country-rock; below these old terraces two or three more recent ones are not uncommonly seen.

Economics.

Slate of a good quality is seen in abundance in the Tuzu and Tepe Rivers. It is used by some of the villages for roofing houses and for grinding purposes; practically the whole of Chimi village is roofed with slate. In a province with a rainfall and humidity like that of Assam, such an excellent material for roofs and "damp-courses" should be invaluable as soon as the Naga Hills are more opened up. None of the asbestos (chrysotile) seen was of any commercial importance.

EXPLANATION OF PLATES.

PLATE 28.

FIG. 1.—Unpolarised light; Magnification 12 diameters.

Hornblende-enstatite-olivine-gabbro (from between Chomi and Chimi), showing hornblende and augite intergrown, and saussuritized felspar (Sec. No. 8928, G. S. I.).

FIG. 2.—Crossed nicols; Magnification 10½ diameters.

Another part of same section, showing intergrown diallage and enstatite, intergrown augite and hornblende, and olivine altering to serpentine with "mesh-structure" (Sec. No. 8928).

PLATE 29.

FIG. 1.—Crossed nicols: magnification 12 diameters.

Hornblende—gabbro (from between Puchimi and Karami), showing diallage bordered with secondary hornblende and labradorite with wedge-shaped twin-lamellae (Sec. No. 8939).

FIG. 2.—Unpolarised light: magnification 12 diameters.

Serpentinized Lherzolite or Picotite-enstatite-diallage-peridotite (from a boulder in the Tuzu river), showing serpentine with immeshed olivine, monoclinic and rhombic pyroxene in lamellar intergrowth altering to bastite, diallage, and the spinellid picotite with a clear border (Sec. No. 8929).

PLATE 30.

FIG. 1.—Unpolarised light: magnification 10½ diameters.
Serpentinized Lherzolite or Picotite-enstatite-diallage-peridotite (from a boulder in the Tuzu river), showing diallage with columnar structure, picotite with its clear border, enstatite altering to bastite and serpentine (Sec. No. 8929).

FIG. 2.—Same section under crossed nicols. The "knitted" structure in the serpentine is well seen (Sec. No. 8929).

PLATE 31.

FIG. 1.—Unpolarised light: magnification 10½ diameters.
Serpentinized Lherzolite or Picotite-enstatite-diallage-peridotite (from a boulder in the Tuzu river), showing enstatite altering to bastite, picotite, diallage etc. (Sec. No. 8929).

FIG. 2.—Crossed nicols: magnification 10½ diameters.
Serpentine (from a boulder in the Tuzu river), showing picotite with clear borders, fragments of decomposing rhombic and monoclinic pyroxene, in a mass of green serpentine (Sec. No. 8935).

PLATE 32.

Geological map of a traverse across the Naga Hills.

NOTES ON INDIAN AEROLITES RECORDED SINCE 1906. BY G. DEP. COTTER, B.A., F.G.S., *Curator, Geological Survey of India.* (With plates 33 to 42).

Since the publication of Dr. Fermor's note in vol. XXXV, page 79, of these *Records*, the following meteoric falls in India have been recorded by the Geological Survey of India :—

(1) *Vishnupur.*—At the villages of Mathura and Kheraibani near Vishnupur, Bankura district, two fragments of a meteorite fell on Friday December 15th, 1906.

(2) *Chainpur.*—On the borders of the Azimgarh and Ghazipur districts, near the villages of Chainpur, Rajgirpura, Rampur Patari, Bhikhampur, and Rao Patti, a fall occurred on May the 9th, 1907.

(3) *Mirzapur.*—This fall took place at Mirzapur village, Saidpur tahsil, Ghazipur district, on January the 7th, 1910.

(4) *Baroti.*—On September 15th, 1910, a meteorite fell on the borders of the Bilaspur and Kangra districts. Two fragments were found at the villages of Baroti (Bilaspur) and Jajri (Hamirpur tahsil, Kangra). Some small fragments from the former village were sent to the Museum.

(5) *Khohar.*—On September 19th, 1910, a meteorite fell at Khohar village (lat. 25° 6′ 20″, long. 81° 31′ 33″) near Bargarh station on the East Indian Railway line to Jubbulpore. The locality lies in the Banda district.

(6) *Lakangaon.*—On November 24th, 1910, a meteorite fell in the Nimar district of Indore State at a village named Lakangaon, apparently identical with Lapangaon (lat. 21° 46′, long. 75° 16′) near Nagelwari.

The object of the present paper is merely to place on record the circumstances attending the falls of these meteorites, with brief notes on their external characteristics. Very little attempt has been made to determine their mineralogical composition.

I.—The Vishnupur Meteorite.

Two fragments of this meteorite were received: the first, weighing 670·4 grammes, which fell at Kheraibani village (lat. 23° 6′, long. 87° 26′), was presented by Babu Atal Behari Bose, Sub-divisional Officer, Vishnupur; the second, which fell near Ramsagar (lat. 23° 6′, long. 87° 20′), weighed 1,767 grammes and was presented by Mr. Kumar Ramendra Krishna Deb, Magistrate of Bankura. The latter officer forwarded an interesting account of the fall, recorded by the Rev. J. Mitchell of the Wesleyan Mission. I cannot do better than quote his report in full:—

" On Saturday, the 22nd December, at the request of the District Magistrate, Bankura, I visited the place where a meteorite fell near Ramsagar, a station on the Bengal-Nagpur Railway in the District of Bankura, and gathered the following particulars:—

" The exact place where the stone fell is not Ramsagar, but by the side of a house in the Banshipara (*para*=quarter: G. deP. C.) of a village called Mathura, 2 miles south-east by east of Ramsagar and 2½ miles north-west of Vishnupur. A round hollow 4 inches deep and 5½ inches in diameter was formed in the ground—ordinary soil—by the falling of the meteorite. This hollow I asked the village people to preserve, and this I think they have done. I questioned the people carefully with reference to the fall. Babu Umesh Chandra Rai, a leading man in the village, stated that about 9·20 A.M. (standard time) on Friday, the 15th December 1906, he heard two loud sounds in the air, sharp and sudden as if two cannons had been fired; then a loud rumbling sound which continued for some 10 minutes, when it ceased at the moment the stone fell. That a loud continuous sound followed the first two reports was borne out by all the villagers whom I saw, and one man insisted that the rumbling sound lasted fully an hour. Thus from the Babu's statement the stone must have fallen about 9-30 A.M.

" One woman was standing within 10 yards of the spot where the meteorite fell. She said she heard a loud continuous sound and then suddenly the whole neighbourhood was filled with dust, and she was so terrified that she ran away. Two men who were

standing about 100 yards away from the woman confirmed her statement.

"When the loud reports were first heard, all looked upwards in that direction, but none of the villagers saw anything in the shape of a stone, nor did anyone see a bright light of any kind in the air.

"An interesting feature in connection with the meteorite is that apparently it was quite cold when picked up. Dry grass was scattered all over the ground where the stone fell, but not a particle was singed. The Babu, above referred to, handled the meteorite almost immediately after it fell, and he stated that it was quite cold, and this statement was confirmed by all the villagers.

"It appears that a second stone fell on the same day at a place called Kheraibani, some 5¼ miles north-east by east of Vishnupur. A glance at the survey map[1] (inch scale) will show that the distance between the two places where the two stones fell is about 6¾ miles. It is evident that these two stones form one and the same meteorite, and that the loud report previous to the actual fall indicated the moment when the stone broke into two or more parts. Probably other stones fell within the same neighbourhood though as far as I know none have been discovered. Naturally great excitement was produced in the village at the fall of such a strange visitor and many were the conjectures as to where it came from, nor was I surprised when I heard that several of the people made deep salaam to the stone when they first caught sight of it, and treated it as if it were a messenger from the gods."

Such is the account of the Rev. J. Mitchell.

The two pieces of the Vishnupur meteorite were registered under the numbers 248 A and B, and weighed respectively 670·4 and 1767·4 grammes. The first and smaller piece is not available for examination. The second and larger piece is figured on Pl. 33, where the picture gives an excellent impression of its shape and of the well-marked pittings or "thumb-marks" upon its surface. The meteorite is almost entirely covered with black crust, showing a finely granulated structure, in which flow-striæ are not visible.

[1] Sheet No. 239 Bengal; scale 1″=1 mile.

One flat surface of the meteorite, not visible in the picture, is bounded by sharp edges (one of the edges forming the right-hand edge of the photographic view) and may represent a plane of fracture, along which the meteorite in its descent was broken in two. There are, however, only very slight indications that the crust is appreciably thinner upon this surface than upon the remainder.

The fresh fractures which are seen at the corners of the specimen show that internally the meteorite is of a light grey colour, and that it presents a motley appearance owing to the presence of minute chondrules of a darker colour than the matrix. There is also a close resemblance to the structure of a volcanic tuff, many angular fragments being visible on the freshly fractured surface.

When placed between the poles of an electro-magnet the meteorite does not appear to be appreciably magnetic, an indication that the nickel-iron is either absent or only present in small quantity.

II.—The Chainpur Meteorite.

This fall took place at about 1-30 P.M. On the 9th May 1907 at a group of villages on the borders of the Ghazipur and Azimgarh districts, the largest fragment falling at Chainpur in the Azimgarh district (lat. 25° 51′, long. 83° 29′), *vide* sheets 194 and 209, scale 1 inch = 1 mile, North-West Provinces Survey.

Accounts of the fall appeared in the *Englishman* of May 15th, 1907, and in the *Rangoon Gazette* of May 16th, 1907.

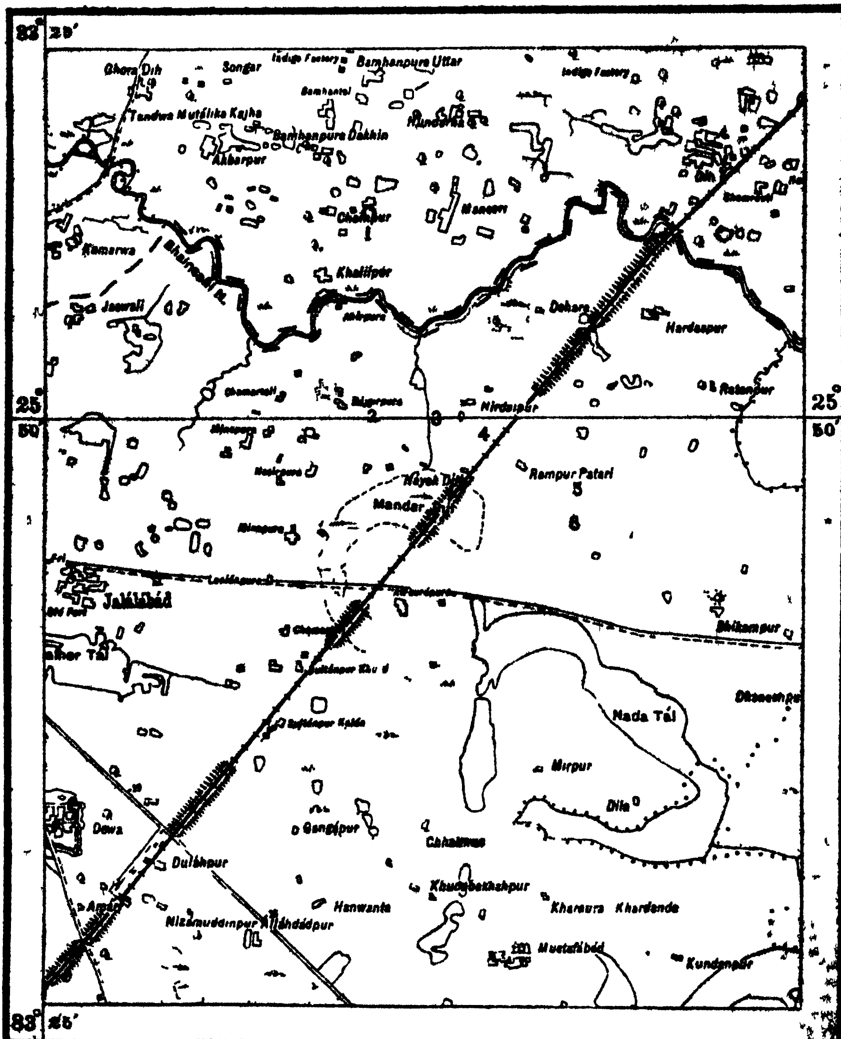
The Collector of Ghazipur forwarded an account of the fall, that is, of that part of it which occurred in his district, near the villages of Bhikhampur, Jalalabad, and Rao Patti. In this account two statements of eye-witnesses are given, and may be here quoted. The first account, by a villager of Bhikhampur, is as follows :—" I was working in my sugarcane field when three successive sounds of cannon and thunder were heard from the sky. Up to the second sound nothing was visible, but after the third one, the sky seemed cleft asunder and a small black ball appeared on the sky which was coming down towards the earth with a whizzing sound. It took the ball about two minutes

to reach the earth. It fell on a fallow land at a distance of about 125 yards from the field. I then at once ran towards the spot and found the black ball sunk about half a cubit deep into the earth, and there were several small fragments of the ball scattered all around. I then touched the ball and found it icy cold. The ball was fragile and could be broken by pressure of fingers. Soon after villagers came in and broke the ball into pieces and went away with as much of it as they could carry. The weight of the ball was about one maund. It appeared to descend from the sky just over my head."

The second statement by a villager of Jalalabad is as follows :— " I also heard the same sound of cannons and thunder and then saw the appearance of a black ball coming to the earth. The ball fell on a sugarcane field at a distance of about 120 yards from where I was working. I too found the ball very cool and its fragments scattered. The soil of the earth had become black and given in. The hollowness of the ground was about 1½ ft. deep and 1 ft. broad. The weight of the ball was probably 12 or 15 seers. The ball was first seen in the sky over my head, and it descended straight to the earth."

It will be observed that there is some discrepancy in these two accounts, both as to the weight of the stone and the depth of the hole made in the earth.

The largest fragment of this meteorite fell near Chainpur village in the Azimgarh district, and thus came into the possession of Miss Sturmer, owner of the Kajha Zemindary, who very generously presented it to the Geological Survey. It weighed 5,372 grammes. Miss Sturmer also had a map prepared showing the places where fragments were found, and states that these different localities were six in number. The account of the Collector of Ghazipur does not quite coincide with that of Miss Sturmer, the fragments obtained from the Collector were said by him to come from the villages of Bhikhampur, Jalalabad, and Rao Patti, but the discrepancy is probably to be accounted for by the situation of some of the localities between two villages. It may thus have been referred to different villages by different observers. A reduction of Miss Sturmer's map, adapted to the 1 inch=1 mile Survey map, is given below.



Sketch Map of the Chainpur Fall, 9th May 1907.

It will be observed that the fall took place along a line running from south-east to north-west; this feature is also noticed by the Collector of Ghazipur.

The Chainpur meteorite is registered under the numbers 249 A to G. The weights are as follows:—

	gms.	
249 A	1,446·46	
249 B	494·46	
249 C	355·23	
249 D	18·73	(dust in tube).
249 E	1,007·03	
249 F	5,372·62	
249 G	8·22	(dust in tube).

Specimens A to D fell on the borders of Nasirpur, a hamlet of Jalalabad, about 1¼ miles to the north-east of Jalalabad, and were sent to the Geological Survey Office by P. Rama Shankar Misra, Collector of Ghazipur. Specimen E was presented by Mr. W. J. Simmons, Calcutta, who received it from Miss Sturmer. F and G fell at Chainpur, and were presented by Miss Sturmer.

The only pieces that show the original black crust are B and F.

Photographs of the Chainpur meteorite are given on Plates 34 to 37 and 38, fig. 2.

The Chainpur meteorite appears to belong to the group of "Kugelchenchondrite" and some of the fragments show a structure which resembles the pisolitic structure of terrestrial rocks. The colour of the freshly fractured surface is a slate grey. Many of the chondri are of a whitish colour and give a mottled appearance to the stone.

Rusty spots are scattered over the surface. The meteorite is attracted by the electro-magnet, and the dust is magnetic; it is therefore probable that a fair amount of nickel-iron is present. The microscope section shows the chondri to be composed of crystals of enstatite and olivine. Nickel-iron is present both in the chondri and in the ground-mass. The ground-mass is mainly composed of an opaque mineral without metallic lustre, possibly graphite. The crust of the meteorite is a dull greyish black, not showing

any varnish effect. In specimen 249 B the surface is striated with ridges and furrows. Pittings are not well marked, the nearest approach to them is seen in specimen 249 F, and are seen at the base of the picture in Pl. 37.

III.—The Mirzapur Meteorite.

On the 7th January 1910, at about 11-30 A.M., another meteorite fell in the Ghazipur district, which has thus the distinction of having furnished two successive meteorites to the Museum. It fell at Mirzapur village in the Saidpur tahsil (lat. 25° 41′ 28″ long. 83° 15′). One piece of this meteorite was forwarded by the Collector of Ghazipur, and registered as specimen 250 A, weighing 8,316·25 gms. or 18·35 lbs. avoirdupois. A second piece was forwarded through Mr. W. J. Meares, registered as specimen 250 B, weighing 208·65 gms.

The Collector of Ghazipur in his forwarding letter notes that no luminous balls were seen in the sky, but that a sound as of thunder or cannon was heard. The meteorite appeared to come from a north-westerly direction. The phenomenon lasted probably a minute. The meteorite appears to have been cold when it was found. The meteorite was found embedded in the earth, with about 6 inches projecting above ground.

Photographs of the two pieces of the Mirzapur meteorite are given on plates 38, fig. 1 and 40.

The crust of this meteorite is grey to grey-black, for the most part dull, but in some patches with a slight varnish. Pittings are well marked. The meteorite is more strongly attracted by the electro-magnet than the Chainpur stone. In one portion, seen imperfectly on the lower left-hand quarter of Pl. 39, is a bronze-lustred opaque mineral resembling pyrites, which gives off H_2S when wetted with acid, and is therefore troilite. The meteorite is full of veins infilled with a black material which gives it a "trapshotten" appearance.[1] In structure the meteorite is chondritic, but the chondri are smaller than in the Chainpur specimen. It contrasts also with the Chainpur meteorite by reason of its compactness as compared with the very friable and crumbly state of the latter.

[1] The term "trapshotten" is familiar to readers of Indian Geology, being applied by Messrs. King and Foote to the veined gneiss of Trichinopoly (*Mem., Geol. Sur. Ind.*, IV, p. 271) and used subsequently by Sir T. H. Holland in his description of the Charnockite series (*Mem., Geol. Sur. Ind.*, XXVIII, pp. 182, 198, 248).

In the microscope section, the veins appear to be composed of an opaque mineral, possibly graphite or magnetite. Nickel-iron and troilite are present. The rock is mainly composed of crystals of enstatite and olivine.

IV.—The Baroti Meteorite.

This stone fell at about 10 A.M. on the morning of the 15th September 1910 at a village named Baroti in Bilaspur, Simla Hill States; another piece fell in Jajri village in the Hamirpur tahsil of the Kangra district, but was not recovered. There are two villages named Baroti in Bilaspur, but I am of opinion that the one indicated is that situated in lat. 31° 37′, long. 76° 48′.

The Wazeer of Bilaspur notes that a cloud of smoke appeared in the sky accompanied by a sound like that of a railway train. A stone weighing 10 to 12 pounds then fell in village Baroti and broke into pieces. There was a strong smell of sulphur after the fall.

The fragments which reached this office are as follows:—

251 A. Weight 36·85 gms.

251 B. Six small fragments which weigh together 8·48 gms.

251 C. One piece weighing 0·882 gms. which has been used in preparing a section.

251 D. Minute fragments and dust in a tube; weight 1·085 gms.

Specimen 251 A shows a very small portion of the crust, which has no varnish or striæ.

The freshly fractured surface is of a whitish colour, with minute metallic grains. The meteorite is strongly attracted by the electro-magnet.

I have been kindly assisted in the examination of the section by Dr. Fermor. The structure is not chondritic. The main mass of the rock is made up of crystals of olivine and enstatite, occurring both as phenocrysts and as minute grains. There are two opaque minerals, one of a bronze lustre is evidently troilite, while the other appears to be nickel-iron.. There are in the ground-mass occasional grains of a mineral of low single and double refringence, which is probably felspar, and also some grains of an isotropic mineral, possibly oldhamite or maskelynite. A third opaque mineral is present in a few small grains. It has no metallic lustre, and is probably graphitic carbon.

A photograph of the largest fragment of the Baroti stone is given on Pl. 42, fig. 3.

V.—The Khohar Meteorite.

This meteorite fell on the 19th September 1910, at about 1 P.M. at Khohar village in the Banda district (lat. 25° 6′ 20″, long. 81° 31′ 33″). A noise like thunder was heard, the report being audible four to five miles away. The pieces of this meteorite were received from the District Magistrate, Banda.

There is one large fragment, nineteen smaller pieces, and two small chips. These are registered as follows:—

	gms.
252 A	530·31
252 B	338·35
252 C	4,819·02
252 D	588·67
252 E	287·56
252 F	223·96
252 G	426·16
252 H	188·3
252 I	239·31
252 J	355·17
252 K	211·51
252 L	224·64
252 M	343·35
252 N	223·38
252 O	138·13
252 P	174·42
252 Q	150·53
252 R	102·51
252 S	100·55
252 U	14·92

Also a microscope section No. 9206.

The crust of the meteorite is pitted and striated. It is dull black in colour. The freshly fractured surface is grey with whitish beautifully-formed chondrules averaging in size the shot grains of a "No. 8" cartridge.

The microscope section shows the chondrules to consist of olivine and enstatite, in small needles often showing radiated arrangement and intergrowth. One chondrule is almost precisely the same as

that figured in Dana's System of Mineralogy, page 348. The chondrules are set in a ground-mass of nickel-iron and troilite, with olivine and enstatite. This meteorite is especially remarkable for the beautiful development of the chondritic structure. Photographs are given on Pls. 41 and 42, fig. 1, whilst photomicrographs of two chondrules are given in Dr. Fermor's paper "Preliminary note on the Origin of meteorites."[1]

VI.—The Lakangaon Meteorite.

The Lakangaon meteorite, which fell about 6 P.M. on the evening of November the 24th, 1910, at a village named Lakangaon, and which is probably identical with Lapangaon (lat. 21° 46′, long. 75° 15′ 30″) near Nagelwari (the headquarters of the Pargana of that name in Native Nimar, part of the Indore State) is especially interesting because it was accompanied by a brilliant flash of light, which was seen at a distance of about sixty miles. An interesting account appeared in the *Pioneer* which I quote:—

This evening about six o'clock as we were sitting outside our tents in the village of Beria ten miles west of Sanáwád on the Rajputana-Malwa Railway, we observed a sudden and extraordinarily brilliant flash of light which quickly dissolved into luminous smoke, similar to that emitted by burning magnesium wire, which remained visible in the sky for over half an hour. The trail of smoke reached nearly to the zenith. About five minutes after the flash there was a loud report followed by a rumbling noise. Presumably this was a very large meteorite, and judging by the time which elapsed between the flash and the report, it must have struck the earth at a distance of about sixty miles south-west of our camp. There is a low range of hills to the west of this village at a distance of about three miles.

(Sd.) C. F. BELL,
Deputy Conservator of Forests.

N. J. ROUGHTON,
Assistant Commissioner.

W. TARR, *Captain, I.M.S.*

R. A. WILSON,
Assistant Commissioner.

[1] *Jour. A. S. B.*, Vol. VIII (1912), Plate 28.

Two portions of this meteorite were forwarded by the Indore Durbar, and are registered as follows :—

	gms.
253 A	125·06
253 B	87·54

There are two tubes of dust.

The second portion of this meteorite is photographed on Pl. 42, fig. 2. It shows a highly varnished black crust, with a network of ridges enclosing miniature pittings averaging one millimetre in diameter. With the lens a few metallic grains can be seen, possibly nickel-iron. A drop of acid placed on the surface of the stone yields a smell of H_2S, indicating the presence of troilite. Chondri are not visible.

EXPLANATION OF PLATES.

PLATE NO. 33.

Vishnupur meteorite, large specimen.

PLATE NO. 34.

FIG. 1.—Chainpur meteorite, showing granular structure.
FIG. 2.—Chinpur meteorite, showing crust.

PLATE NO. 35.

Chainpur meteorite, showing granular structure.

PLATE NO. 36.

Chainpur meteorite, showing crust and granular structure; reduced to $\frac{3}{4}$.

PLATE NO. 37.

Chainpur meteorite, showing crust; reduced to $\frac{3}{4}$.

PLATE NO. 38.

FIG. 1.—Mirzapur meteorite, small fragment with crust.
FIG. 2.—Chainpur meteorite, showing granular structure.

PLATE NO. 39.

Mirzapur meteorite, showing the vein of troilite (left hand quarter) and the trapshotten effect; reduced to $\frac{3}{4}$.

PLATE NO. 40.

Mirzapur meteorite, large piece; reduced to $\frac{3}{4}$.

PLATE NO. 41.

The Khohar aerolite, largest fragment, showing portion of the crust; reduced to about ½.

PLATE NO. 42.

FIG. 1.—The Khohar aerolite, smaller fragment, showing striated crust.

FIG. 2.—The Lakangaon aerolite, largest fragment, showing wrinkling of the crust.

FIG. 3.—The Baroti aerolite, largest fragment.

MISCELLANEOUS NOTES.

Eruption of a submarine Mud Volcano off Sandoway, Arakan Coast, Burma. (With map, plate 43.)

On the night of the 2nd March 1912, (the night of the full moon of Tabaung, 1273, Buddhist Era), an eruption of a mud volcano occurred on or near the Hlaing Bauk Kon, a submerged reef situated to the south of Cheduba, some 3 miles out to sea from the village of Singaung, Sandoway District, Arakan.

This reef is known to Europeans as the "Drunken Sailor Rocks" and its exact position is shown on the accompanying plan. One Mg. U. Kyaw of Singaung has testified, that on the night mentioned sounds resembling thunder were heard from the sea, and that in the morning a new island was seen to have been formed at the Hlaing Bauk Kon. Maung U. Kyaw and two other Burmese villagers took a boat and attempted to land on the island, but were unable to do so owing to the roughness of the sea.

The ejected material covered about a quarter of an acre and was composed of sand and gravel, doubtless held together by the viscous mud which characterises these eruptions and enables their products to resist the action of the sea for a longer or shorter time. No gas or oily matter appears to have been evolved, but the waters to the west of the newly formed island were discoloured with mud. At the time of the eruption the state of the weather and sea is reported to have been normal. By the beginning of May 1912 the island had been washed away.

It thus appears that the raising of the "Drunken Sailor Rocks" by a "volcanic" disturbance which was reported at the time in the Press of India and Burma, is to be accounted for by the accumulation of mud, sand, and gravel, on the reef itself, from an eruption of a sub. marine mud volcano somewhere in the near vicinity.

I am indebted to Commander A. R. G. Willock, R.I.M., Port Officer, Akyab, and to the Deputy Commissioner, Sandoway, for details of their investigations.

[J. COGGIN BROWN.]

Fiery Eruption of a Mud Volcano on Foul Island, Arakan Coast, Burma.

Details have recently reached the office of the Geological Survey of India regarding the fiery eruption of a mud volcano on Foul Island, off the Arakan coast of Burma in November 1911. It is desirable to record this in the general list of such occurrences.

Mr. J. A. deRozario of the Public Works Department, Kyeintali, Sandoway District, reports that about the month of November 1911,—the exact date not being remembered,—he was on tour in the Gwa sub-division, when he was called up to witness an eruption on Foul Island, out to sea just opposite his headquarters at Kyeintali. Flames rose to a height of 30 or 40 feet for over 5 minutes, suddenly subsided for 2 or 3 seconds, and then burned high again for a further 2 minutes. The times were taken with a watch. The whole sea was lighted up and great volumes of smoke were evolved which could be seen as clearly as in daylight,—the eruption apparently took place at night. The phenomenon which is described as very beautiful, was witnessed and worshipped by 20 or 30 Burmese villagers, who also informed Mr. deRozario that eruptions take place on the island every 4th or 5th year. The only other recorded eruption of Foul Island which I have been able to trace, is that of the 24th February 1908, which is chronicled on the chart of the east coast of the Bay of Bengal, Sheet 2, Cheduba Strait to Kuronge Island. Its position is shown on a small map accompanying my previous note.

The following reference to Foul Island is taken from the Gazetteer of the Sandoway District published in October 1912,[1]—"Twenty-three miles off Bluff point which is at the mouth of the Kyeintali river there is an uninhabited island known as Foul Island, and by Burmans as "*Nan-tha-Kyun.*" Both names are derived from a mud volcano which gives the island its conical appearance, and from which at times of eruption pours a strongly smelling torrent of hot mud bubbling with marsh gas. Beginning from early in 1908 eruptions also occurred along the line of reefs, [which dot the southern portion of Sandoway coast along its entire length], and prevented steamers from calling at Sandoway for three years.

[J. COGGIN BROWN.]

Gas from a Mud Volcano in Mekran.

The sample of gas was kindly sent by W. A. Johns, Esq., C.I.E., Engineer-in-Chief, Karachi Extension Railway Survey, who obtained it from one of a group of mud volcanos " about 15 miles north-east of the town of Or Mora in Mekran. They have no particular name but are near the place

* *Burma Gazetteer*, Sandoway District, vol. A, by W. B. Tydd, p. 2 (Rangoon, 1912).

marked Gwaz on the four miles to the inch map of Mekran." I have not been able to find a description of the group in question. E. Vredenburg has given a general account [1] of the mud volcanos of the Mekran coast and references to earlier literature are to be found in his Geological Sketch of the Baluchistan Desert.[2] Such detailed descriptions as there are refer chiefly to the Hinglaj group, about fifty miles eastward.

The gas was under considerable pressure in the sample bottle, which was evidently well sealed. It consisted of :—

74·5	per cent.	of	methane,
8·9	,,	,,	ethane,
0·7	,,	,,	unsaturated hydrocarbons,
1·4	,,	,,	carbon dioxide,
0·7	,,	,,	oxygen,
13·8	,,	,,	nitrogen.

It contained no carbon monoxide and no hydrogen was found by combustion over palladium asbestos.

The composition of the combustible residue, after the absorption of unsaturated hydrocarbons with fuming sulphuric acid, has been calculated on the assumption that it consists of methane, CH_4, and ethane, C_2H_6 ; it is possible that still higher homologues of the paraffin series may be present, but the important point is that the gas contains a considerable percentage of a member or members of the paraffin series with a higher carbon content than marsh gas. The presence of marsh gas alone might be ascribed solely to decaying organic matter in the mud, but the existence of higher hydrocarbons suggests a much less recent origin for the gas supply, and indicates the possibility of association with still higher, liquid, hydrocarbons. In view of the statement of Boverton Redwood [3] that "the mud volcanos of the Mekran coast are instances in which no trace of petroleum exists," the observation may not be without interest.

A small quantity of an evil-smelling green "scum" from the crater of the same mud volcano was forwarded with the gas by Mr. Johns. The liquid portion was an aqueous solution, chiefly of common salt, with a subsidiary quantity of magnesium and calcium salts and a little sulphate. The rest consisted mainly of diatoms and bacteria, living and dead, with small particles of clay. Liquid hydrocarbons were not detected in the ethereal extract from the scum, but the quantity submitted for investigation was insufficient for a definite assertion of their absence.

[W. A. K. CHRISTIE.]

[1] *Baluchistan District Gazetteer Series*, VIII; Las Bela; p. 15, (Allahabad, 1907).
[2] *Mem., Geol. Surv. Ind.*, XXXI, (1901), p. 285.
[3] *Petroleum*, second Ed., I, p. 118, (London, 1906).

INDEX TO VOLUME XLII.

Photo by H G Herring

Bemrose Collo, Derby

Ostrea gryphoides Schlotheim.

Miocene. *Vienna Basin.*

(Copied from Hoernes' work, reduced ⅓).

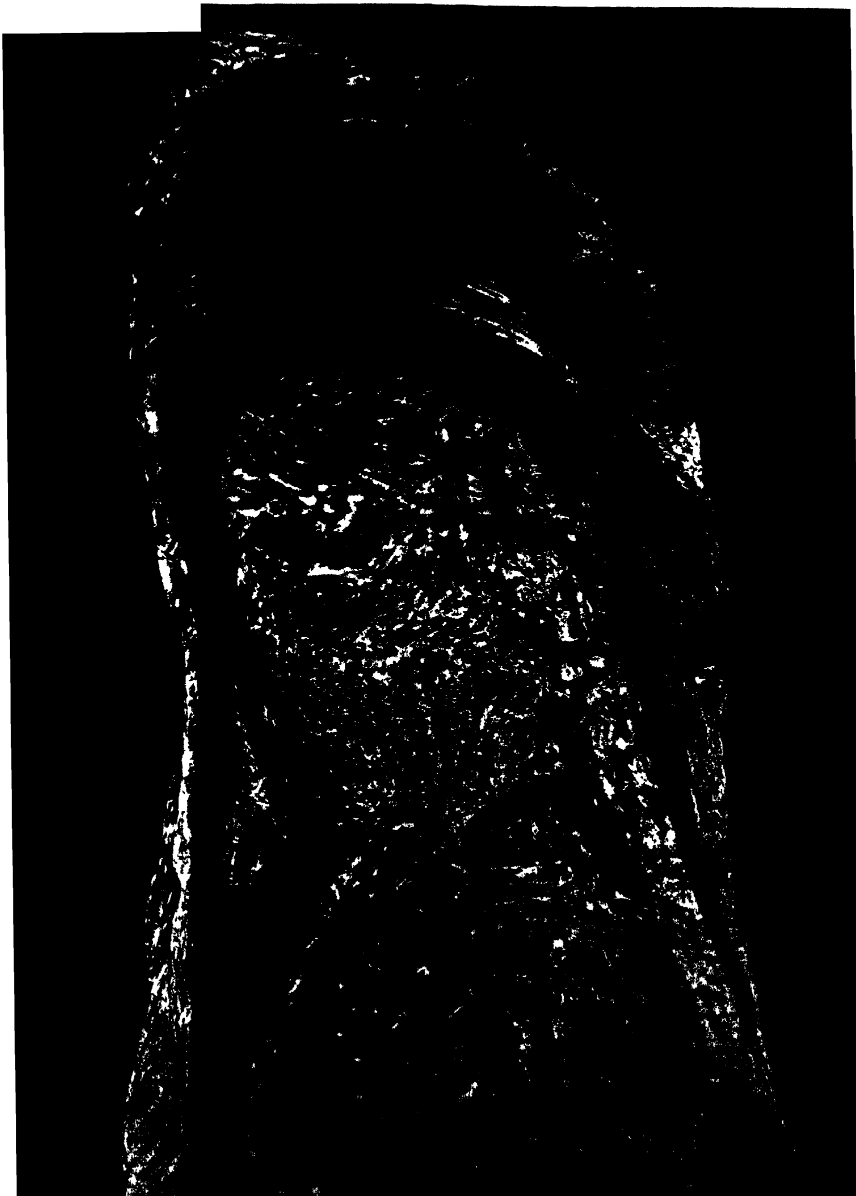


Photo by H G Herring

Bemrose Collo, Derby

Ostrea gryphoides Schlotheim

Miocene *Algeria*

($\frac{2}{3}$ nat)

Photo by H G Herring

Bemrose Collo., Derby

Ostrea gryphoides Schlotheim

Recent *Calcutta excavations*

($\frac{2}{3}$ nat)

Photo by H G Herring

Bemrose Collo Derby

Ostrea gryphoides Schlotheim

Recent *Bay of Bengal (Mergui)*

($\frac{2}{3}$ nat)

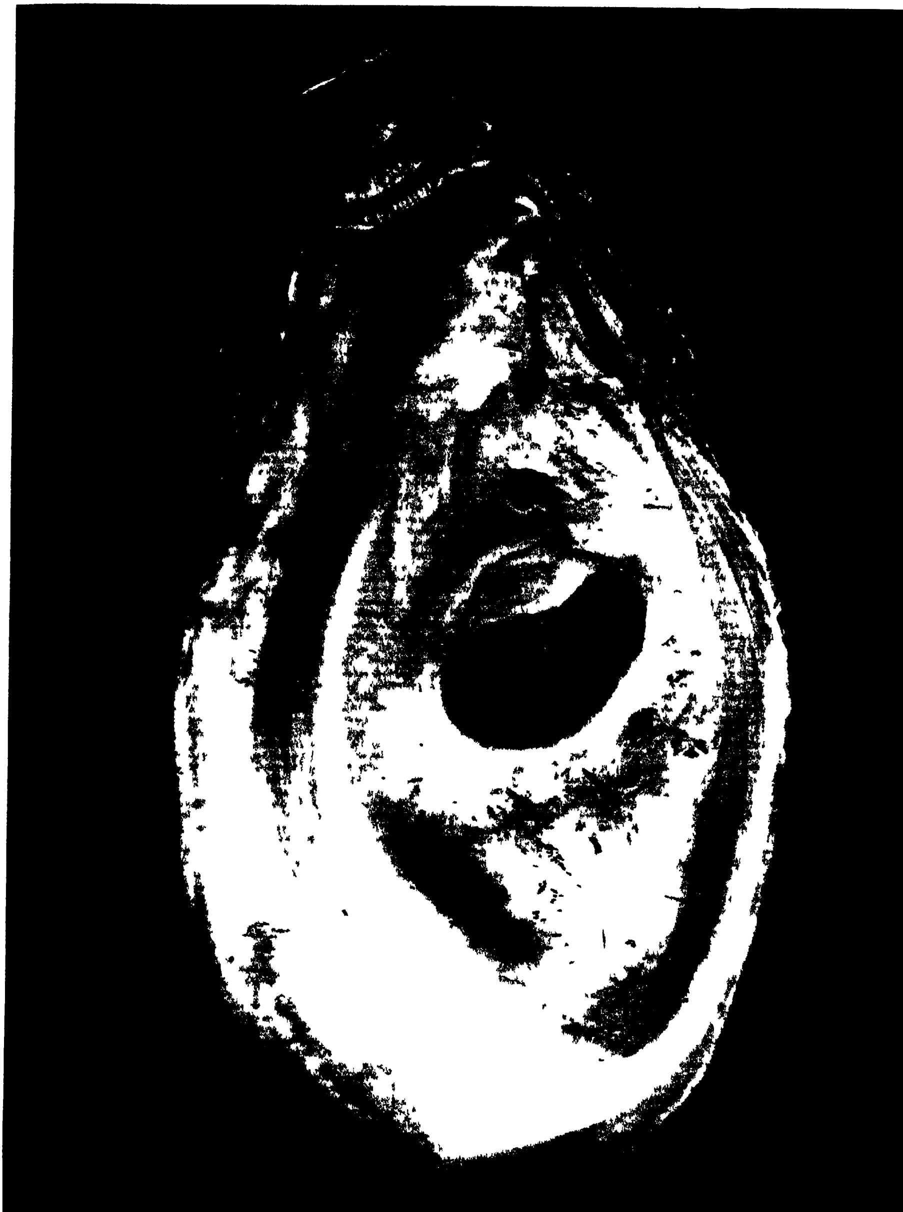


Photo by H G Herr ng

Bemrose Collo Derby

Ostrea gryphoides Schlotheim

Recent *Bay of Bengal (Mergui)*

($\frac{2}{3}$ nat)

Photo by H G Herring

Bemrose Collo Derby

Ostrea gryphoides. Schlotheim

Recent *Bay of Bengal (Mergui)*

($\frac{2}{3}$ nat)

Photo by H G Herring

Bemrose Collo Derby

Ostrea gryphoides var cuttackensis var nov

Recent *Bay of Bengal (Cuttack Coast)*

(⅔ nat)

Photo by H G Herring

Bemrose Collo Derby

Ostrea gryphoides var cuttackensis var nov

Recent (⅔ nat)

A–*Bay of Bengal (Cuttack Coast)*

B–*Calcutta excavations*

A H Searle del et lith

West, Newman imp

SILURIAN FOSSILS FROM KASHMIR

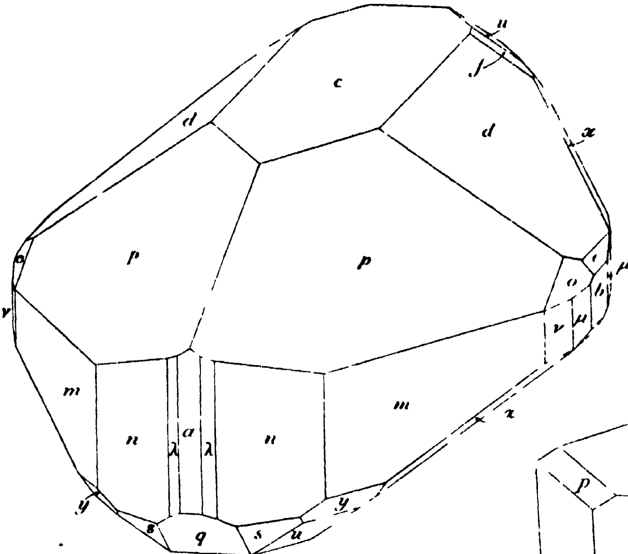


Fig. 1.

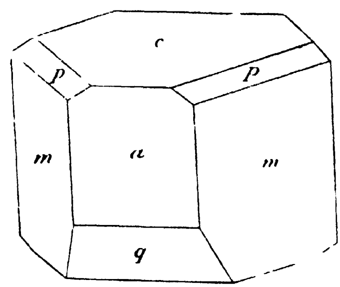


Fig. 3.

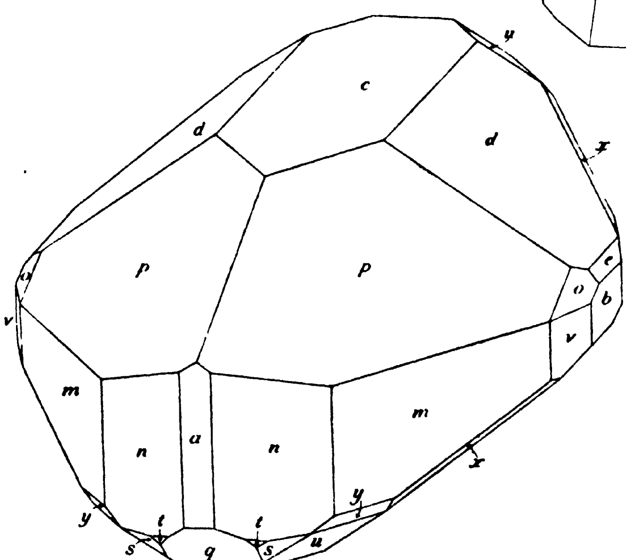


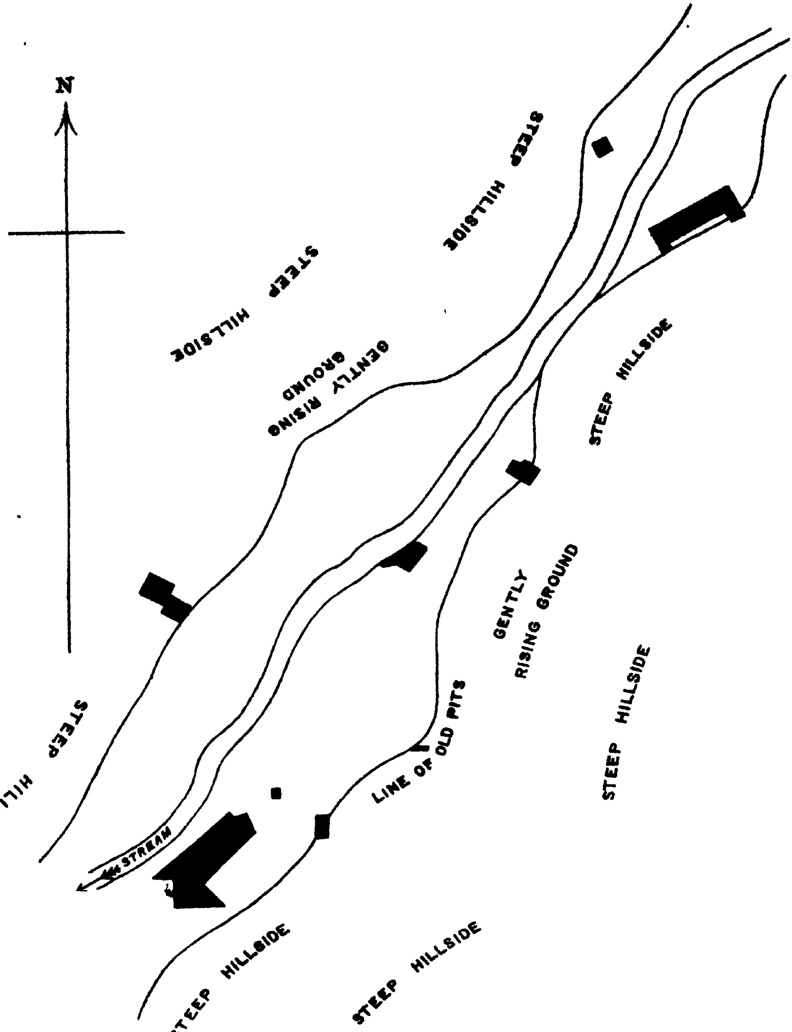
Fig 2.

BLÖDITE FROM THE SALT RANGE.

J. C Brown, Photo

G S I Calcutta.

SHANS WASHING AURIFEROUS GRAVEL AT HWE-GNA-SANG



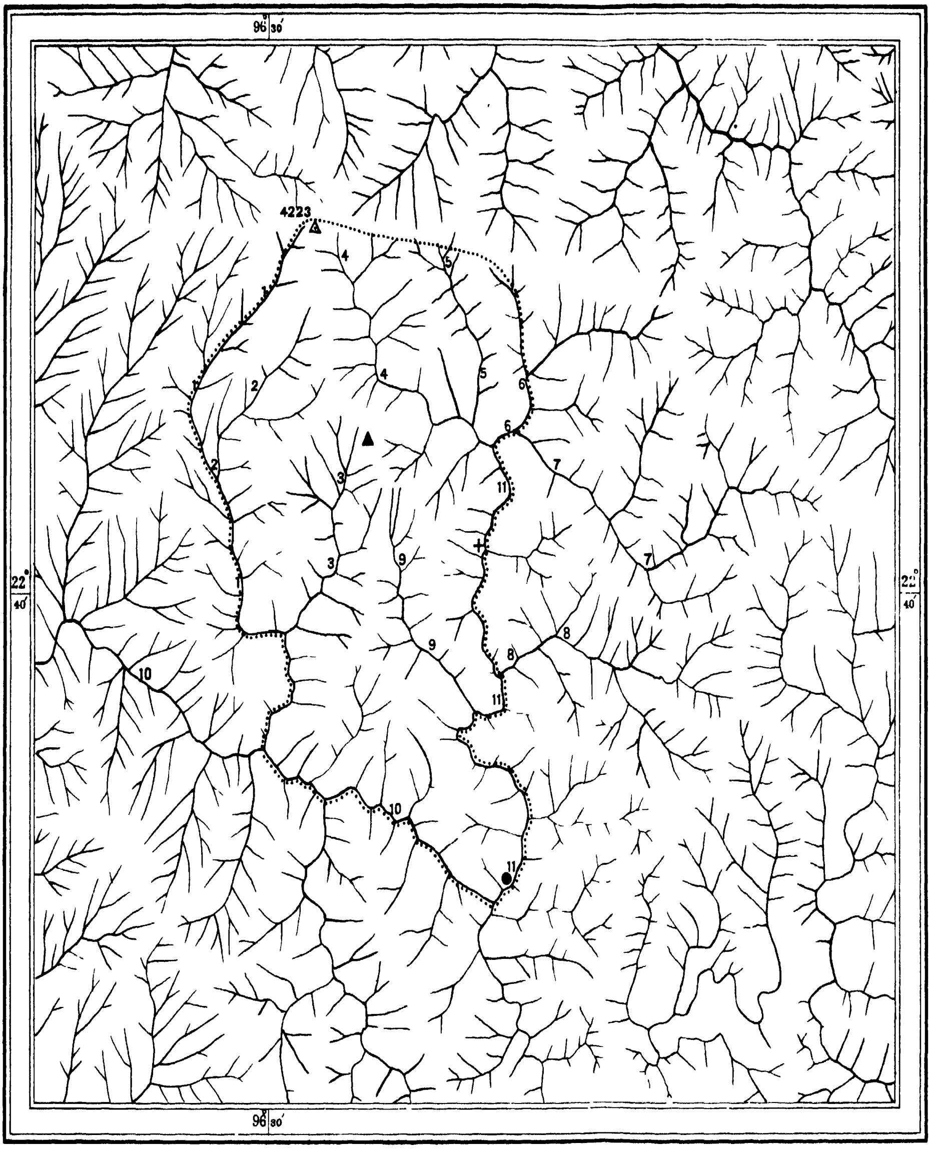
HWE-GNA-SANG DEPOSIT.

Showing Shan Workings April 1911.

Scale, 1" = 198 Feet.

Chain and compass Survey.

Records, Vol. XLII, Pl. 13



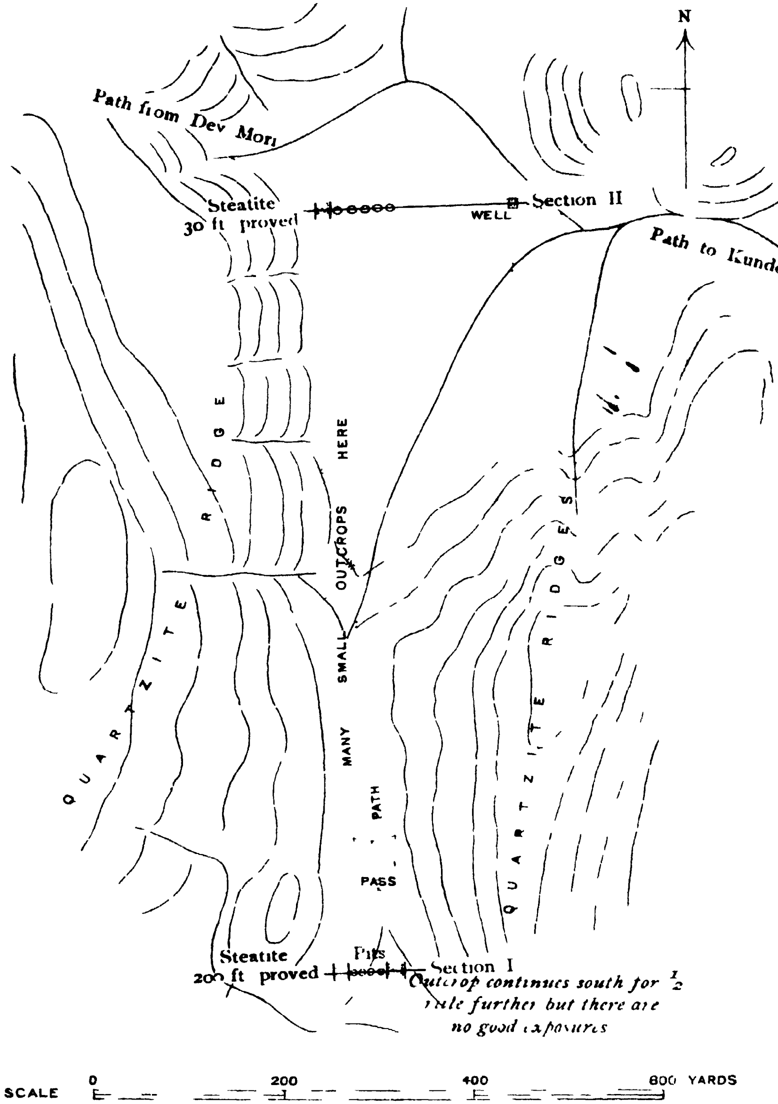
Names of Streams etc.

1 — Hwe-hkam-long.
2 — Hwe-po-la.
3 — Hwe-som-kuan.
4 — Hwe-pung.
5 — Hwe-mi-pang
6 — Hwe-um-na.
7 — Hwe-ma-chi-nw
8 — Hwe-mang-mwn.
9 — Hwe-hin-tap
10 — Nam-e-wa.
11 — Hwe-gna-sang.
● — Sawbwa's Camp.
▲ — Hto-hei
+ — Kung-wo ?
△ — Loi-sar.

HWE-GNA-SANG CONCESSION

(The area within the black dots.)

Scale, 1″ = 1 miles



PLAN OF STEATITE OCCURRENCE

Topography roughly
inserted from
1 inch = 1 mile survey sheet,
to indicate exact locality.

T A BROCK DEL

Bemrose Collo Derby

Phyllites kamarupensis sp nov

Records, Vol. XLII. Pl.
Part 2.

4

5

5A(×3)

6

T A Brock Del. Bemrose Collo., Derby

Phyllites kamarupensis sp nov Fig 4
Phyllites sp Figs 5 6

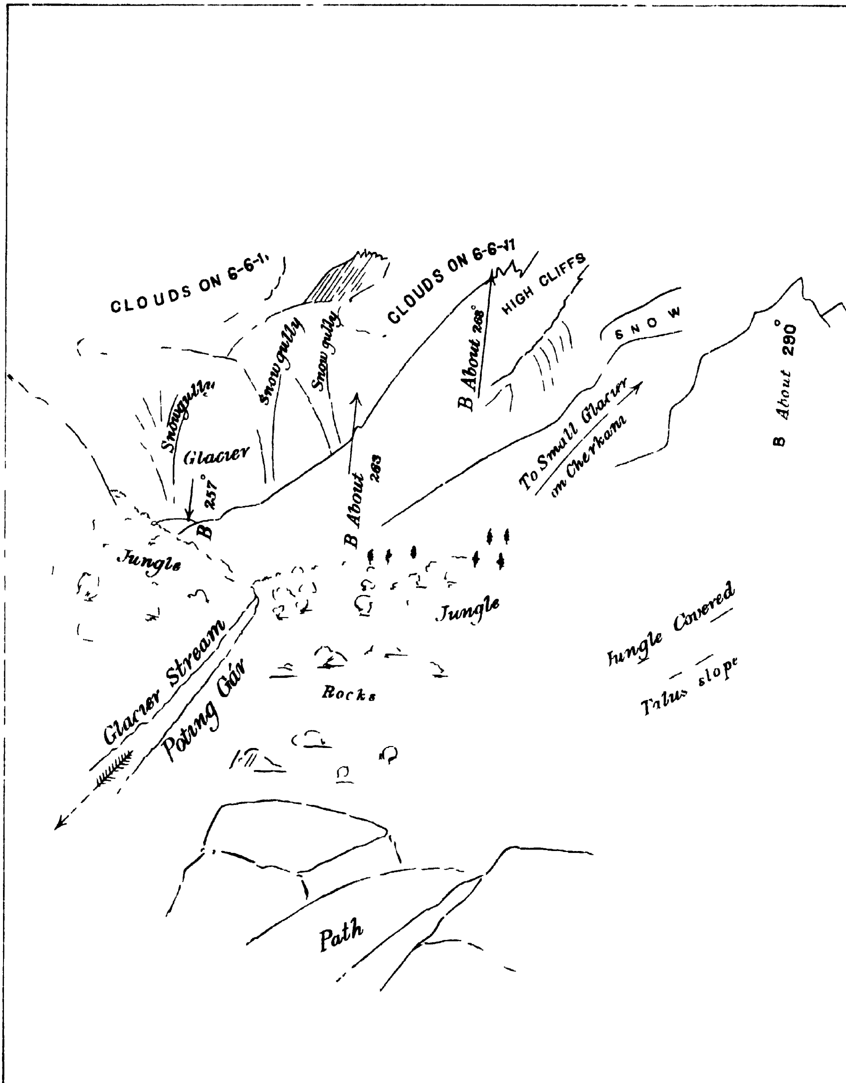


Fig. 11.—SKETCH SHOWING BEARINGS OF CERTAIN PROMINENT FEATURES FROM POINT WHERE THE VALLEY COMMENCES TO OPEN OUT

at 2nd mile from Bugdiar.

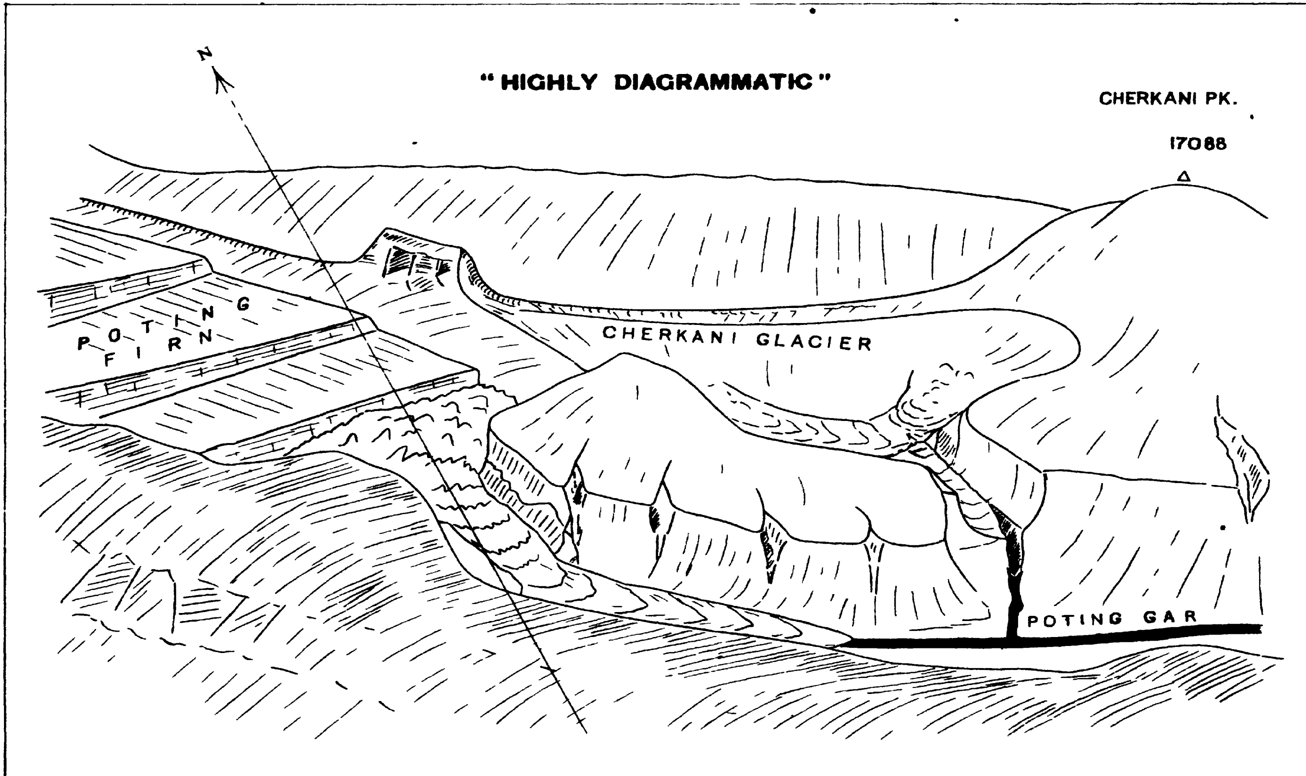


Fig. 15 — DIAGRAM SHOWING THE FEATURES OF THE CHERKANI GLACIER VALLEY.

M B 339 (Meridian of 1911)

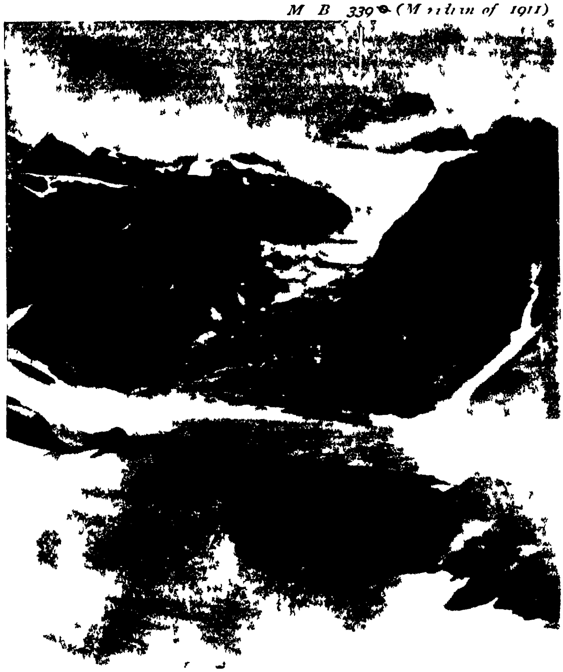
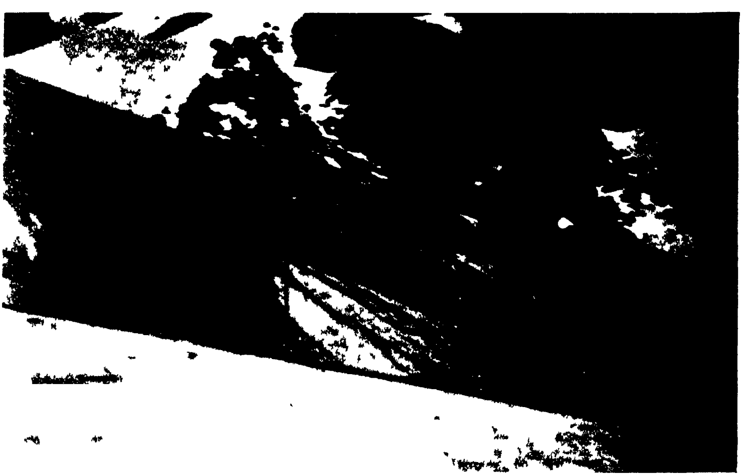


Fig 14 POTING ICE FALL FROM ⊙888 7th JUNE 1911



M B 347° (Meridian of 1911)

Fig 17.— SNOUT OF POTING GLACIER FROM ⊙C[2] 7th. JUNE 1911

J L Grinlinton, Photo G S I Calcutta

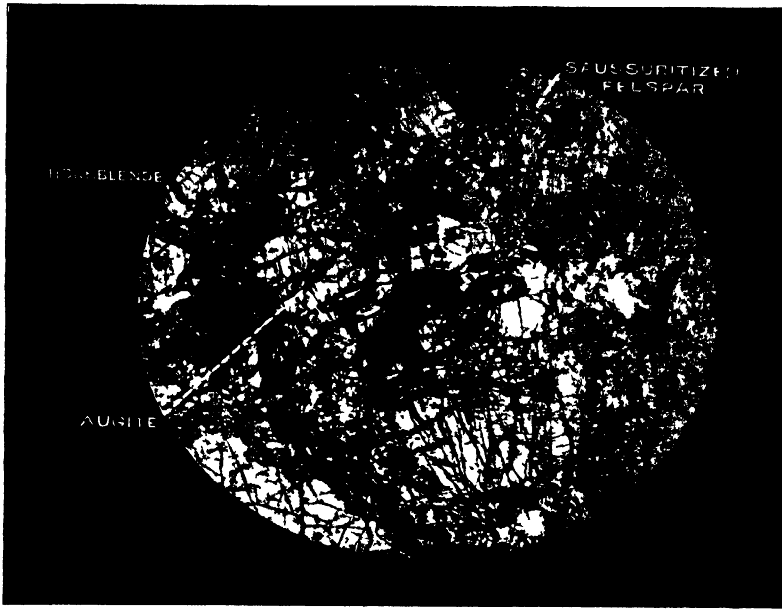
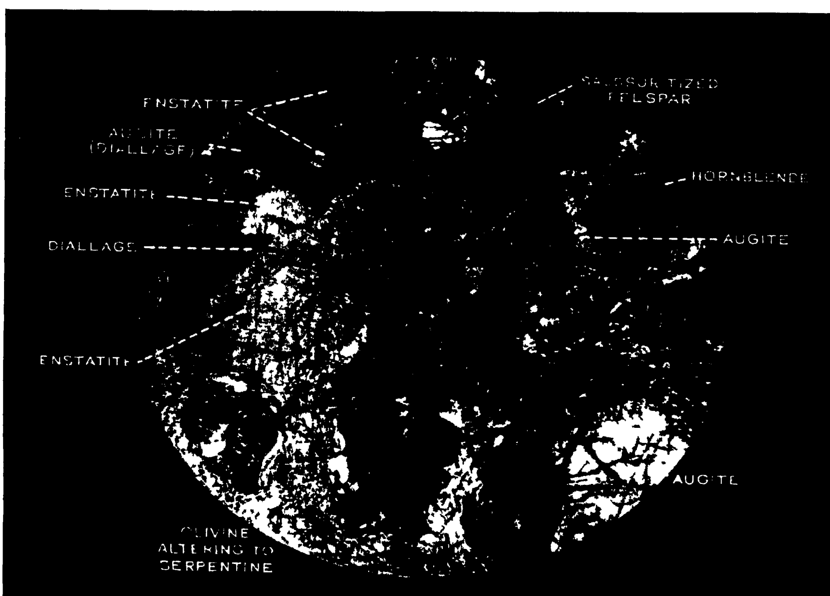


Fig. 1. GABBRO (× 12 diam)



E. H. Pascoe, Photo   *G. S. I. Calcutta*

Fig. 2. SAME GABBRO (× 10, diam crossed nicols)

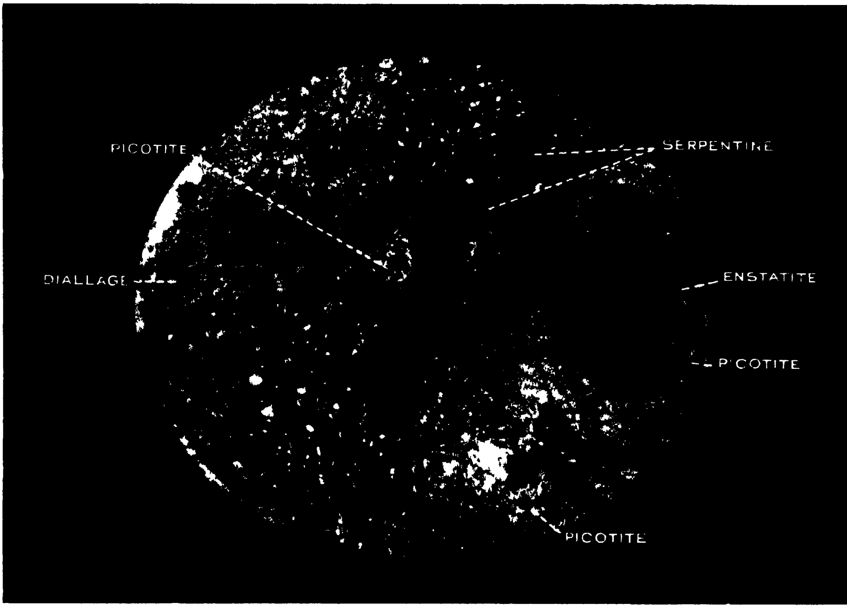
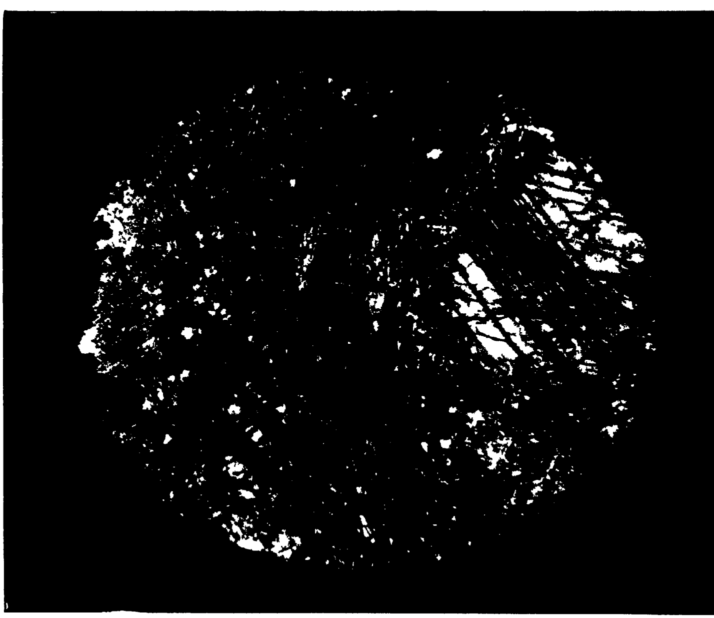


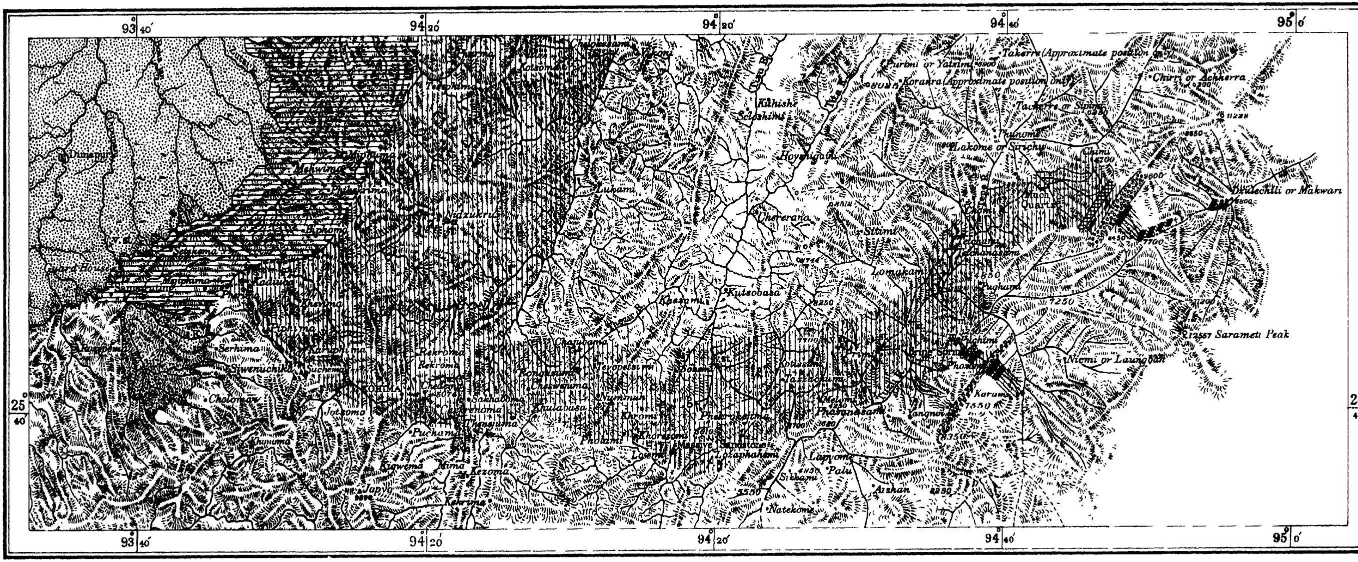
Fig. 1. SERPENTINIZED LHERZOLITE. (× 10' diam.)



E. H. Pascoe, Photo

G. S. I. Calcutta.

Fig. 2. SAME SECTION WITH CROSSED NICOLS.



Recent	
Tipam series	
Coal measures	
Disang Shales	Disang series
Green Grit	
Chimi Conglomerate	
Serpentine, peridotite etc.	
Makwari (? Axial) beds	

Dips: m — moderate; g. — gentle; st. — steep; v. st. — very steep

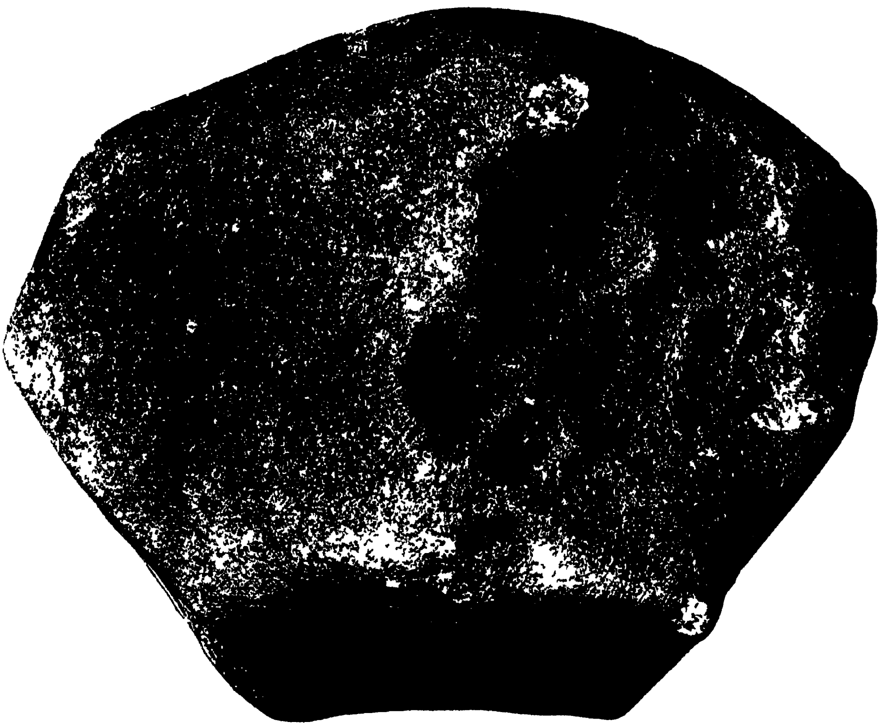
Approximately vertical strata

" horizontal strata

GEOLOGICAL MAP OF A TRAVERSE ACROSS THE NAGA HILLS.

Scale, 1 inch = 8 miles

(The traverse is joined up with Mr. Hayden's mapping to the north.)



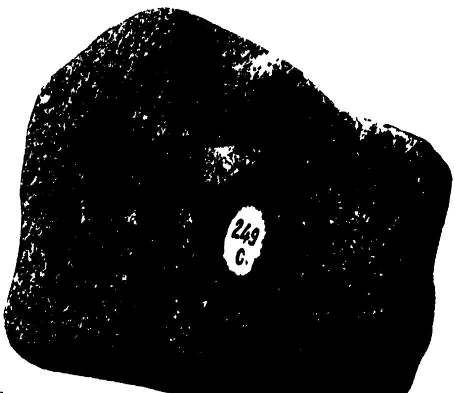
H. B. W. Garrick, Photo.

G. S. I. Calcutta.

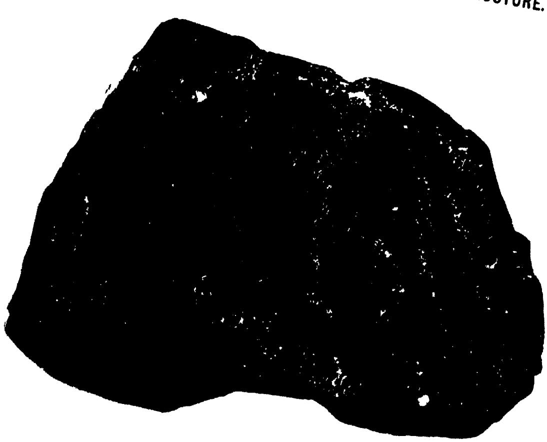
VISHNUPUR METEORITE.

Large specimen.

Natural Size.



CHAINPUR METEORITE SHOWING GRANULAR STRUCTURE.

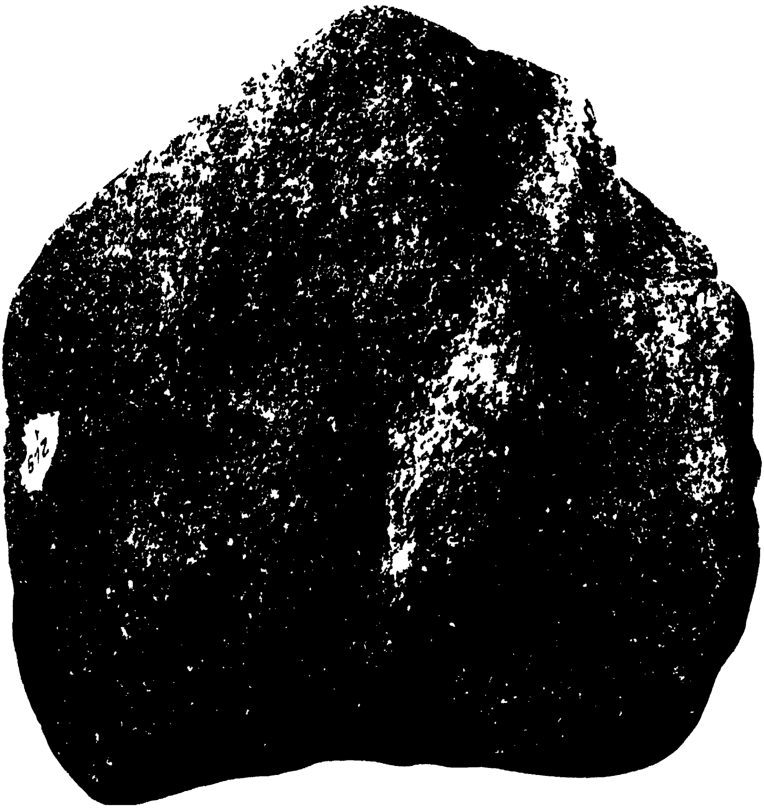


H. B. W. Garrick, Photo.

CHAINPUR METEORITE SHOWING CRUST.

Natural Size

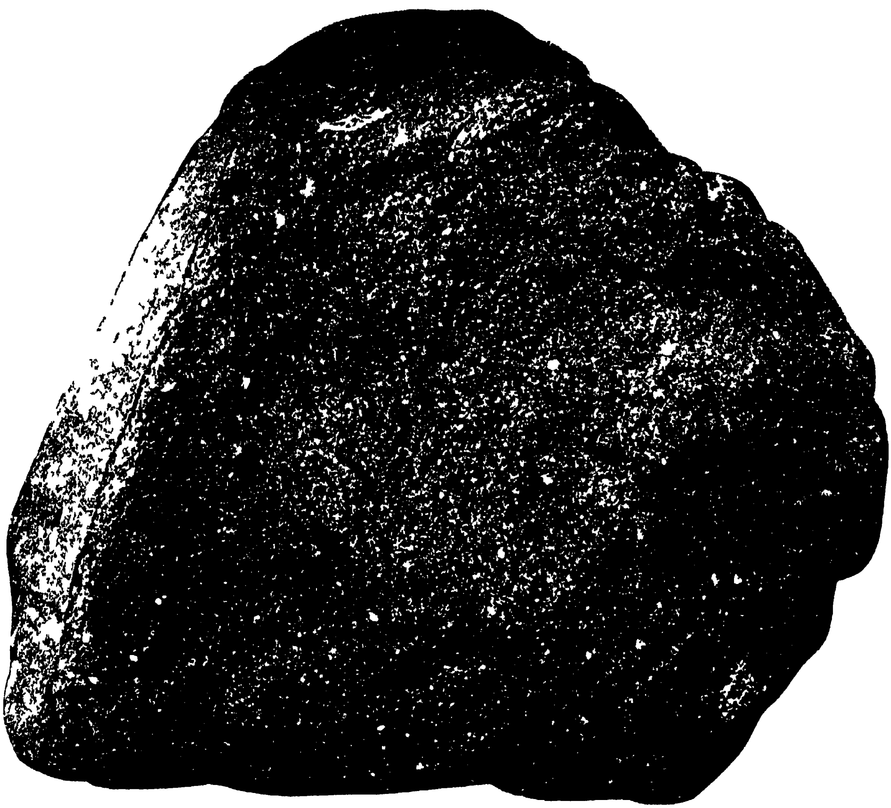
G. S. I. Calcutta.



H. B. W. Garrick, Photo. *G. S. I. Calcutta*

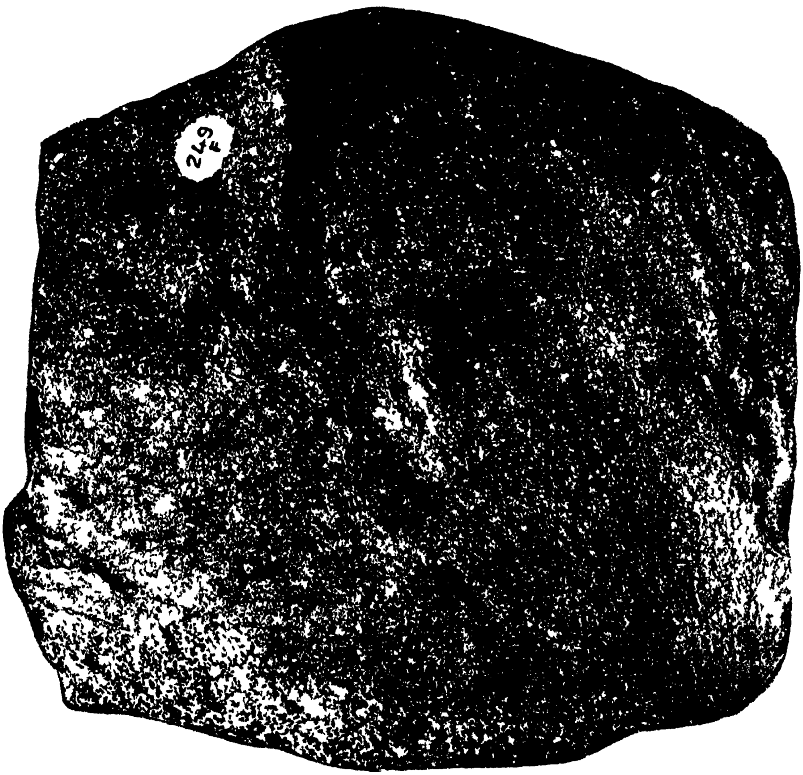
CHAINPUR METEORITE SHOWING GRANULAR STRUCTURE.

Natural Size



H B W Garrick, Photo G. S. I. Calcutta

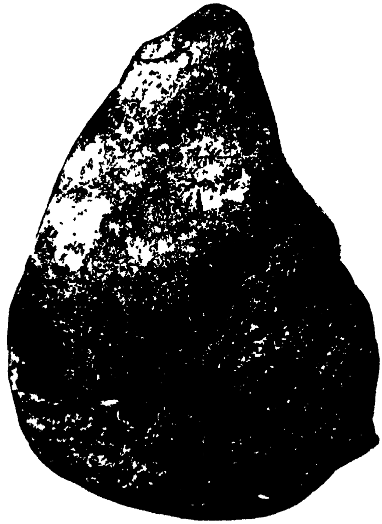
CHAINPUR METEORITE SHOWING CRUST, GRANULAR STRUCTURE.



H. B. W Garrick, Photo. *G. S. I. Calcutta.*

CHAINPUR METEORITE SHOWING THE CRUST.

[illegible] *Natural Size.*

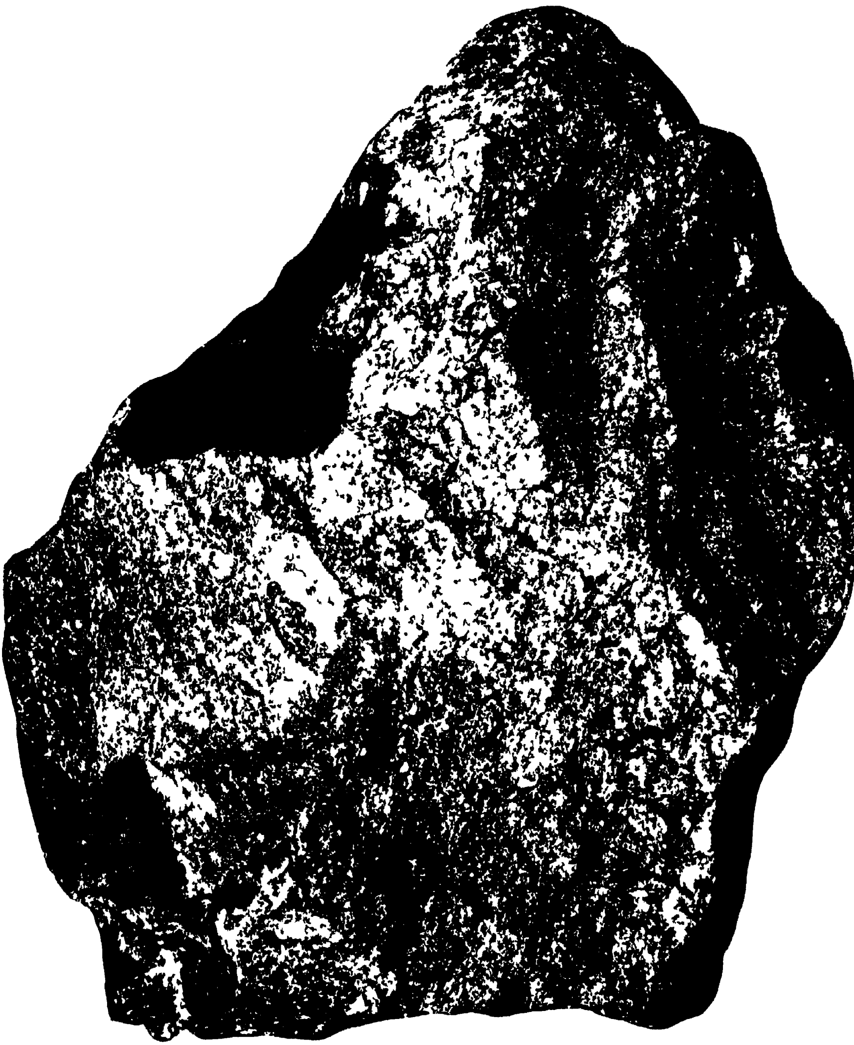


MIRZAPUR METEORITE, SMALL FRAGMENT WITH CRUST.

H. B. W. Garrick, Photo. G. S. I. Calcutta.

CHAINPUR METEORITE, SHOWING GRANULAR STRUCTURE.

Natural Size.

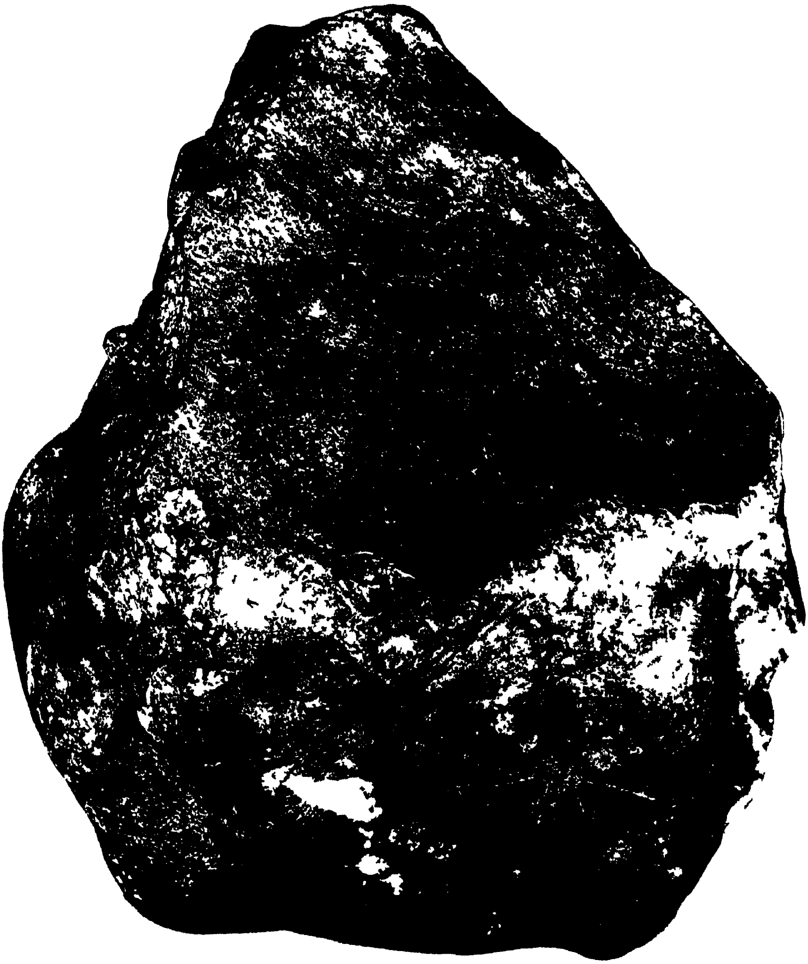


H B W. Garrick, Photo　　　　　G S I Calcutta.

MIRZAPUR METEORITE

SHOWING THE VEIN OF TROILITE (lefthand quarter) AND THE "TRAPSHOTTEN" EFFECT

¾ *Natural Size.*



H. B W Garrick, Photo.

G S I Calcutta

MIRZAPUR METEORITE.

Large piece.

¾ Natural Size.

H. B. W. Garrick, Photo. *G. S. I. Calcutta.*

THE KHOHAR AEROLITE, LARGEST FRAGMENT, SHOWING PORTION OF THE CRUST;

Reduced to about $\frac{1}{2}$.

Fig. 1.

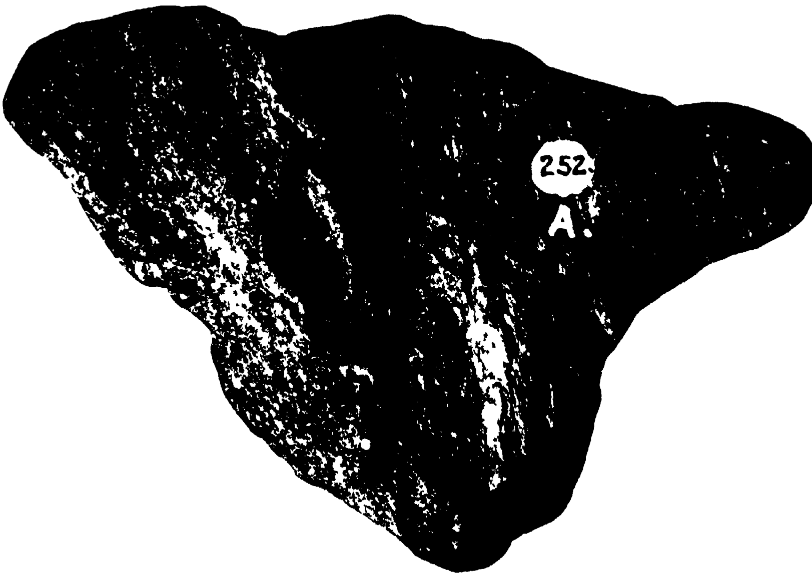


Fig. 2.

Fig. 3.

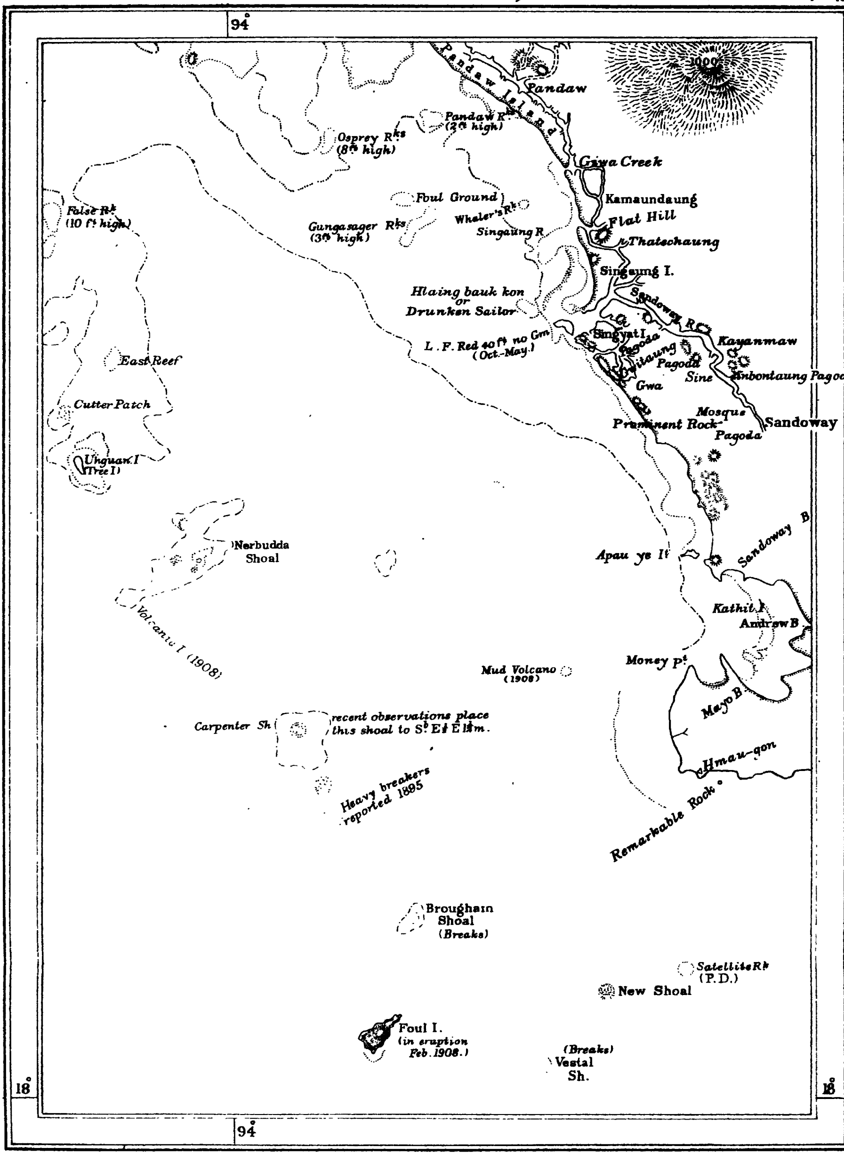
H B W Garrick, Photo.

G. S. I. Calcutta.

Fig. 1. THE KHOHAR AEROLITE, SMALLER FRAGMENT, SHOWING STRIATED CRUST.

Fig. 2. THE LAKANGAON AEROLITE, LARGEST FRAGMENT, SHOWING WRINKLING OF THE CRUST.

Fig. 3. THE BAROTI AEROLITE, LARGEST FRAGMENT.



PART OF SANDOWAY COAST SHOWING POSITION OF HLAING BAUK KON OR "DRUNKEN SAILOR" SHOAL.
FROM BAY OF BENGAL-EAST COAST CHART (Sheet II).

Scale, 1 inch = 5½ miles approx.

CALCUTTA
SUPERINTENDENT GOVERNMENT PRINTING, INDIA
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